Henry Smith Palmer M.R.C.S. Eng.
Newlake

THE

PHYSIOLOGY OF DIGESTION

CONSIDERED WITH RELATION TO THE

PRINCIPLES OF DIETETICS.

BY

ANDREW COMBE, M.D.,

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NINTH EDITION,

EDITED, AND ADAPTED TO THE PRESENT STATE OF PHYSIOLOGICAL AND CHEMICAL SCIENCE,

BY

JAMES COXE, M.D.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF EDINBURGH.

"Nor is it left *arbitrary*, at the will and pleasure of every man, to do as he *list*; after the dictates of a depraved *humour* and extravagant *phancy*, to live at what rate he pleaseth; but every one is bound to observe the *Injunctions* and *Law of Nature*, upon the penalty of forfeiting their *health*, *strength*, and *liberty*,—the true and long enjoyment of themselves."

MAINWAYRINGE.

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DEDICATION.

TO

GEORGE COMBE,

AUTHOR OF "THE CONSTITUTION OF MAN CONSIDERED IN RELATION TO EXTERNAL OBJECTS," &c.

My Dear George,

On the eve of departure to a foreign clime, in search of that health which I may never find, I gladly seize the opportunity of dedicating the present volume to you, in grateful remembrance of the happiness derived from our life-long and unclouded friendship. There are other reasons which concur to render such a dedication peculiarly appropriate. It is mainly to your advice and influence that I am indebted for perhaps the most valuable parts of my general and professional education, and consequently for all the advantages which I have derived from them. It is to the example of your untiring zeal in the discovery and diffusion of useful truths, and in the cause of human improvement, that I owe much of the deep interest which I have long felt in similar pursuits. And, lastly, if this or any other of my published works has proved useful in diminishing the sum of human suffering, or in adding to the means of human enjoyment, it is in a great measure to you that I owe the gratification of having been of some service to my fellow-men; for without your cheering encouragement to urge me on at the beginning, it is doubtful whether any one of my volumes would ever have been written. To you, therefore, I have great pleasure in addressing this dedication, as a sincere expression of the gratitude, esteem, and regard, with which I remain,

My Dear George,

Your very affectionate Brother,

ANDREW COMBE.

Edinburgh, *October* 15. 1842.

THE AUTHOR'S ADVERTISEMENT

TO THE

FIFTH EDITION.

Since the first publication of this work, four editions, amounting together to nearly 8000 copies, have been sold in this country. In the United States also it has enjoyed a very wide circulation. This success is very gratifying, as it affords an encouraging indication that the importance of physiological knowledge as a branch of general instruction is every day becoming better understood and more extensively recognised.

In the third edition various improvements were effected. Of these the most important was the introduction of a new chapter, explaining more fully the relation subsisting between the different kinds of food and the principal varieties of the human constitution. Several other improvements, of a still more extensive kind, and in which I intended to turn to account such of the recent discoveries in organic chemistry as have a more direct bearing on the practical principles it was my object to expound, had also occurred to me, as calculated to increase the utility of the work and place it on a level with the science of the day; but these I have not been able to effect to the extent I contemplated and wished. When engaged in preparing this edition for the press, a recurrence of severe and protracted indisposition obliged me to desist, and left me no hope of being able to accomplish my original design, without a much longer delay than it seemed prudent to incur, as the work had already been several months out of print, and numerous applications had been made to me, urging its immediate republication. Nevertheless, I have been able to introduce many improvements, especially in the first half of the work, which had undergone a careful revision before my labours were interrupted: among these may be specified the insertion of what I think will be found a useful chapter on the "Conditions required for securing Healthy Digestion." As the mode of treating the subject of the present volume is in many respects new, and more practical in its character than that followed in other works; and as it seems to me to suggest means of farther improvement, of which others may avail themselves; I trust that most readers will concur with me in thinking that I have decided correctly in not delaying the republication of the volume, and awaiting the uncertain event of restored health and ability to render it more complete.

The same motive which induced me to reprint "The Principles of Physiology applied to Health and Education" in a cheaper form—an earnest desire to render it accessible to all classes of the community—has induced me to follow a similar course with respect to the present edition of this work. The continued extensive circulation of the former treatise, in the shape of a "People's Edition," and the many applications I have received from persons wholly unknown to me for a cheap edition of that now in the hands of the reader, have satisfied me that I ought to adopt this plan. But here I have chosen the smaller size of page, as more pleasant and convenient for use and reference.

Lastly, I think it necessary to repeat on this occasion a caution given in the preface of the former work, as to the spirit in which the following pages ought to be read by those whose object in perusing them is not merely to occupy a passing hour. The subjects treated of embrace so many important facts and principles of action, which are comparatively new to the general reader, that it is only by their careful and frequent study that he can become sufficiently familiar with them to avail himself, to the full extent, of the applications of which they are capable to the purposes of self-education and improvement, and to the preservation or recovery of health. To read merely as one reads a novel or a newspaper, can be productive of but little solid or permanent advantage; and therefore, while I value highly the grateful tribute implied in *endeavouring to act* (it may be, in silence) upon the principles I have unfolded, I feel indifferent to even the most eloquent and laboured eulogium, when it is not accompanied by any practical results. I am the more anxious to enforce this view, because many will, I believe, read with increased interest and advantage, after their attention has been thus earnestly directed in the very outset to the practical character and aim of the work.

EDINBURGH, 15*th April* 1845.

THE EDITOR'S ADVERTISEMENT

TO

THIS EDITION.

During the interval of two years which elapsed between the publication of the fifth edition of this work and the Author's death on 9th August 1847, his strength, unfortunately, was at no time adequate to the accomplishment of his wish to revise and improve it in such a manner as "to place it on a level with the science of the day." In consequence, the sixth, seventh, and eighth editions, which were called for in rapid succession, and have brought up the total British circulation of the work to above 16,000 copies, were merely new impressions of the edition to which the foregoing advertisement was prefixed. Shortly before his death, Dr Combe expressed a desire that I should undertake that revisal of his works which he saw it would never be in his own power to effect. In making this selection of an editor, he probably was influenced by the consideration that, from long and familiar intercourse with him, I was well acquainted with the views which guided him in the practice of his profession and in the composition of his popular writings, and heartily concurred with him in attaching deep importance to the diffusion, among the public at large, of a general knowledge of the structure and functions of the body, and the causes by which its health and efficiency are preserved or impaired. Knowing that, during many years, he had been to me a "guide, philosopher, and friend," he may have thought that, after his death, I would make every effort in my power to maintain the scientific accuracy, the clearness and earnestness of exposition, and the practical tendency, which he himself had uniformly aimed at, and which are generally allowed to characterise his works in a degree seldom equalled, and perhaps never surpassed, in any popular treatises on science. With the desire thus expressed by my lamented Uncle, I felt it impossible to refuse compliance, however distrustful of my ability to perform with success the duties imposed on me. The reader has now before him the first-fruits of my editorial labours; and, whatever defects may appear, I have at least done what I could to justify the Author's choice, and to sustain the high reputation of his work. The volume has undergone, throughout, a severe and searching revisal; and while, on the one hand, I have not found it necessary to delete passages beyond the amount of three pages in all, on the other hand the additions which have been made extend to about thirty-six

pages. My leading aim has been to introduce, in pursuance of the Author's unfulfilled intention, a statement of the doctrines of the modern school of organic chemistry, so far as they bear upon the composition of food and the nature of the digestive process. Considerable difference of opinion still exists on many points connected with this department of physiology; but, though occasionally stating the opposite views, I have in general thought it better simply to give those which appeared to me most probable, rather than incur the risk of confusing the general reader with controversial statements. The popular nature of the work frequently prevented me from entering into details which would have been called for in a more scientific treatise. The additions on the subject referred to are contained principally in Chapters III. and XII., the former of which is entirely new. Other additions are scattered elsewhere throughout the volume; but as my object in making them has been to amplify statements already made, to correct such as have been shewn by recent discoveries to be erroneous, and to illustrate and enforce, by new examples, the rules laid down by the Author for the preservation of health, they in no way alter the former character of the work; and the present volume is therefore to be regarded as in all essential respects the production of Dr Combe. The chief passages for which I am responsible, besides Chapter III., treat of the following subjects:—Effect of narcotics upon the appetite, pp. 7-8; Chemical action of saliva, p. 19; Absorption by the bloodvessels of the stomach and bowels, pp. 29, 37; Chemical character of the gastric juice, pp. 48-9; Intestinal digestion, pp. 55, 126; Artificial digestive liquor, pp. 58-9; Changes of the chyme in the intestines, pp. 61-63; Process of assimilation, p. 63; Influence of the nervous system on digestion, pp. 113-14; Properties of different kinds of food, pp. 127-33—of fibrinous food, p. 138—of vegetable food, pp. 143-4, 145-50; Effects of cod-liver oil, pp. 158-60; Causes of bad health in the prison of Nîmes, pp. 164-6; Impurities in water, pp. 171-4; Spirits not the most effectual means of protection from cold, pp. 178-9; Bowel-complaints, pp. 183-5. I have considered it more advisable to point out the chief additions here, than to indicate every new passage at the place where it is introduced; for, as my sentences are frequently interwoven with the Author's, any attempt of this kind must have been but partial, and the reader's attention would have been often and needlessly distracted. In order to preserve, however, as far as possible, a marked distinction between the Author's dicta and my own, I have carefully abstained from writing in the first person singular.

J. C.

EDINBURGH, 15*th March* 1849.

PREFACE.

The present volume is essentially a continuation of the work of which the thirteenth edition has lately appeared, under the title of "The Principles of Physiology applied to the Preservation of Health, and to the Improvement of Physical and Mental Education;" and its object is the same—namely, to lay before the public a plain and intelligible description of the structure and uses of some of the more important organs of the human body, and to shew how information of this kind may be usefully applied, not only in the prevention of suffering, but in improving the physical, moral, and intellectual condition of man. Books on diet and indigestion have long been favourite objects of study with the general public, and, in consequence, every age has produced its own supply of them. Excellent, however, as are many of the precepts which they contain, it cannot fail to have struck the reflecting reader, how very trifling their influence has been, and continues to be, in altering the mode of life of those classes to whom they are addressed. Among the causes which may be assigned for this, the most powerful is perhaps the force of mere habit, which makes any change disagreeable, and prompts to the continuance of those practices in which we have long indulged. But the fact may also be fairly ascribed, in no small degree, to defects in the works themselves; in most of which attention is directed almost exclusively to the abstract properties of the different kinds of food and drink, while the principles on which their adaptation to individual cases ought to be regulated, and by observance of which digestion may be promoted or retarded, have either been altogether neglected, or been treated of so cursorily that no adequate sense of their practical importance has been conveyed. This defect is the more remarkable, because daily experience shews that the observance of the physiological conditions by which digestion is regulated, is practically of far more consequence to health than strict adherence to the use of any one kind of food. So true is this, that, under ordinary circumstances, variety in diet is well known to be conducive to soundness of digestion; and except when the continued use of the same aliments is required on account of disease, the uniformity debilitates rather than invigorates the digestive organs.

Another influential cause of the little regard paid to dietetic rules,

is the imperfect manner in which they are generally enunciated,—as mere *precepts or opinions*, unconnected with, and unsupported by any reference to, the physiological laws from which they are deduced. The fact is, that, in common with the organism as a whole, every organ of the body has a specific constitution, and is regulated in its action by fixed laws. In each tissue there is a tendency to persist in a state of health, unless forced into morbid action by influences foreign to itself; and there is also a tendency, when it is disordered, to take on a course of action calculated to regain the healthy condition. The great organs of the body, with the names of which the public is familiar, and on the harmonious action of which general health depends, are composed of combinations of tissues, and in their aggregate form each of them is endowed with a power of self-preservation, and a capacity for performing a special function, such as digestion or respiration, calculated to promote the welfare of the general economy. The action of every tissue thus contributes, by virtue of its natural constitution, both to its own preservation, and to the function of the compound organ into the formation of which it enters. By the same law, the action of every compound organ contributes in like manner both to self-preservation and to the more general welfare of the body. Every one of these actions is regulated by fixed laws, appointed by divine wisdom; and our success in avoiding causes of disease, and in removing them when they come into action, will greatly depend on the extent of our knowledge of the nature and laws of the tissues and those of the compound organs, and their relations to each other and to external objects. In teaching dietetic rules and hygienic observances, therefore, the precepts delivered should be connected with and supported by constant reference to the physiological laws from which they are deduced. Thus viewed, they come before the mind of the reader as the mandates of the Creator; and experience will soon prove that, by his appointment, health and enjoyment flow from obedience, and sickness and suffering from neglect and infringement of them. It is chiefly from overlooking the principles by which the action of the different organs is regulated in reference to their individual conservation and their ministration to the great welfare of the system, that, even in our best works, the relation subsisting between the constitution of the human body on the one hand and the qualities of the alimentary substances on the other, and the physiological conditions under which digestion is successfully carried on, are so rarely referred to in laying down rules for our guidance; and yet, without keeping these conditions constantly in view, it is impossible to regulate properly the adaptation of diet in any individual case. From this oversight, while the attention is carefully directed to the consideration of the abstract qualities of the different kinds of aliment, little or no regard is paid to the relation in which they stand to the individual constitution, as modified by age, sex, season, and circumstances, or to the observance of the fundamental laws of digestion. And hence, although

these conditions are not unfrequently of much greater importance to the general health than even the right selection of food, yet, when indigestion arises from neglecting them, the food alone is blamed, and erroneous conclusions are drawn, by relying on which upon future occasions, we may easily be led into still more serious mistakes.

It is, indeed, from being thus left without any guiding principle to direct their experience, and test the accuracy of the precepts laid down to them for the regulation of their conduct, that many persons begin by being bewildered by the numerous discrepancies which they meet with between facts and doctrine, between counsel and experience,—and end by becoming entirely sceptical on the subject of all dietetic rules whatever, and regarding them as mere theoretical effusions, based on fancy, and undeserving of a moment's consideration.

The true remedy for this state of things is, not to turn away in disgust and despair, but to resort to a more rational mode of inquiry—certain that, in proportion as we advance, some useful result will reward our labours. Such, accordingly (as is more fully explained in Chapter VIII.), has been my aim in the present publication; and if I shall be found to have been even moderately successful in attaining it, I shall rejoice in the confident belief that the reflecting reader will find many of his difficulties removed, and that other inquirers will be led to still more positive and beneficial results than I have been able to attain. Utility has been my great object throughout. In following what I conceive to be an improved mode of investigation, based on physiological principles, I have, in some instances, placed known facts in a new point of view, and deduced from them practical inferences of considerable value and easy application. But beyond this I am not ambitious of originality; and if I have anywhere used expressions which may seem to do injustice to others. it has been entirely without any such design, and I shall be prompt to acknowledge my error and rectify the involuntary mistake.

From this explanation of the objects of the work, the reader will be warned at the very outset, that it is no part of my intention to occupy it with a detailed description of all the substances used for the nourishment and support of man. Knowledge of this kind, like that of remedial agents, is indispensable to the physician; but, in its minute details at least, it is of secondary importance to the non-medical public, and therefore has no claim on our attention in a work designed chiefly to unfold principles of conduct, the applicability and importance of which to the preservation of healthy digestion is the same, whatever be the kind of food on which the individual subsists. In the recent treatises of Londe, Pereira, Truman, Bryant, and others, the reader will find ample infor-

mation on the various articles of food and drink; and to them, therefore, I beg leave to refer him.

In the previous editions of this volume, I stated that I had derived great advantage from a very valuable work by Dr William Beaumont of America, which—though faulty in its arrangement, and necessarily defective in many essential particulars—contains an authentic record of some of the most curious and instructive observations which have ever been made on the process of digestion. That excellent and enlightened physiologist had the rare good fortune to meet with a case where an artificial opening into the stomach existed, through which he could see every thing that took place during the progress of healthy digestion; and, with the most disinterested zeal and admirable perseverance, he proceeded to avail himself of the opportunity thus afforded of advancing human knowledge, by engaging the patient, at a heavy expense, to live with him for several years, and become the subject of numerous and carefully conducted experiments. Having, through the kindness of a friend resident in the United States, been early favoured with a copy of the original work, I felt so strong a conviction of the superior value of investigations conducted under circumstances so unusually free from the many sources of error inseparable from most experiments on animals, that, at the time, I had almost resolved to reprint it entire, both as an act of justice to Dr Beaumont, and as a valuable contribution to physiological science. In the belief, however, that a republication would immediately appear from some other quarter, I abstained from doing so, and contented myself with making free use of such parts of it as seemed most calculated to throw light upon the practical questions which I was engaged in discussing. But after waiting in vain for two years, and finding the interest excited by Dr Beaumont's experiments increase in proportion as their nature and value became more extensively known, by means of the extracts given in the present volume, I felt it due to Dr Beaumont to delay no longer, and accordingly republished his work with the addition of various explanatory and practical notes;* and the high favour with which it has been welcomed by the leading medical journals, shews that I did not exaggerate its importance.

Dr Beaumont's work being thus rendered accessible to the English reader, I was desirous to omit, in the subsequent editions of the present treatise, a great portion of the matter formerly extracted from it. But on making the attempt, I found many of the extracts so mixed up with the practical conclusions which they were used to enforce, that I could not leave them out without materially weakening the argument. I have,

* Experiments and Observations on the Gastric Juice and the Physiology of Digestion, by William Beaumont, M.D., of the United States Army. Reprinted with Notes by Andrew Combe, M.D. 1 vol. post 8vo. Edinburgh, 1838.

therefore, retained nearly the whole of them; and an additional reason for doing so was, that Dr Beaumont's volume is in the hands almost exclusively of professional men, and is thus likely to remain almost as little known to the general reader, as if it were still confined in circulation to the other side of the Atlantic.

Objections may be stated to several of the repetitions which occur in the following pages. The only apology I have to offer for them is, that I committed them deliberately, because they seemed necessary to ensure clearness, and because the intimate manner in which the different functions are connected with each other, sometimes made it impossible to explain one without again referring to the rest. My prime objects being to render the meaning unequivocally plain, and impress the subject deeply upon the reader's mind, I thought it better to risk in this way the occasional repetition of an important truth, than to leave it in danger of being vaguely apprehended, or its true value unperceived. For these reasons, it is hoped that the fault—if such it is—will be readily forgiven.

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CHAPTER I

GENERAL REMARKS ON WASTE, GROWTH, AND NUTRITION.

Waste or loss of substance always attendant on action—In the vegetable and animal kingdoms waste is greater than in the physical—Living bodies are distinguished by possessing the power of repairing waste—Vegetables, being rooted in one place, are always in connection with their food—Animals, being obliged to wander, receive their food at intervals into a stomach—Nutrition most active when growth and waste are greatest—In vegetables the same causes which increase these processes also stimulate nutrition—But animals require a monitor to warn them when food is needed—The sense of Appetite answers this purpose—The possession of a stomach implies a sense of Appetite to regulate the supplies of food.

AMONG the properties by which living bodies are characterised, there are perhaps none more remarkable than those which have reference to the reception and assimilation of their food. Without continually receiving supplies of nourishment, and without a power of *assimilating* (from *similis*, like—*making into like*) or converting that nourishment into their own living structure, neither animals nor vegetables could continue to exist. In all animals, accordingly, however rudimentary their form, and even where no trace of brain, heart, lungs, spinal marrow, or other distinct organization, can be discovered, some provision for the reception and assimilation of food is uniformly to be met with. In the lowest of all, indeed, the entire being seems to be little else than an apparatus for nutrition.

It is not difficult to discover the reason of this never-failing provision. At every instant of time a change in the constituent elements of the animal body is going on. Every movement and every vital act are accompanied by a corresponding change in the organs by which they are performed. After having served its appointed purpose, the old material separates from the living structure, returns under the dominion of purely chemical laws, and is *excreted* or thrown out from the body in the form of new compounds, the continued presence of which in the system would prove hurtful, and even destructive to life. In whatever act we may be engaged, even in the very act of breathing, organic change and organic waste are invariable concomitants, and the greater the activity, the more rapid the change and waste; and, consequently, the greater the need of fresh supplies of nourishment to replace the loss. Of these facts, we have familiar examples, both in the rapid wasting away of the body under severe muscular exertion, especially when food is not supplied in sufficient quantity; and in the very small waste which goes on when animal life is at its lowest ebb, as during the sleep of hybernating animals. Constituted as we are, indeed, it is as impossible for animal activity to go on without a corresponding organic waste, as it is for any form of combustion to go on without a proportional consumption of fuel.

Such, then, being the unalterable law of animal life, it is plain, that, without a corresponding and continually recurring supply of nourishment to repair the waste consequent on activity, and without the power of assimilating that nourishment, decay and death would speedily ensue. But it is not merely for the purpose of replacing waste materials that fresh supplies are required. Liebig, in his late interesting researches into animal chemistry, has advanced strong grounds for believing that a considerable portion of the food we consume is necessary more for the purposes of respiration than of direct nutrition, and that it chief object is *the production of animal heat*—a requisite not less important than nutrition itself for the support of

animal life. Liebig goes even farther than this, and attempts to shew that the changes undergone by the food, during its assimilation and subsequent progress through the system, are in reality the conditions on which organic activity and all the phenomena of life directly depend. But although Liebig's inferences are not less probable than ingenious and profound, they are based on considerations too exclusively chemical, and too little supported by evidence derived from the observation of the living functions, to warrant their unreserved adoption. Occasionally, also, his physiological premises are so partial and imperfect, if not purely theoretical, as to excite distrust in the reasoning founded on them. Under this conviction, I consider it more prudent, in a popular work like the present, to confine my attention as much as possible to such truths only as may be easily understood and applied to practice, and not to risk confusing the mind of the unprofessional reader by the introduction of facts or doctrines, which, however probable in themselves, may, on farther investigation, require to be set aside as unfounded.

Waste of substance, as an inseparable accompaniment of action, is not peculiar to *living* bodies. It is a universal law of nature, and is equally conspicuous in the *inanimate* world. So well, indeed, is this connexion understood, that it is an important aim in mechanics to reduce, to the lowest possible amount, the loss of substance consequent upon motion. But beyond this point of resemblance between dead and living bodies, a remarkable difference presents itself. In the inanimate world, what is once lost or worn away is lost for ever. There is no power inherent in the piston of the steam-engine by which it can repair its own loss of particles; and consequently, in the course of time, it must either be laid aside as useless, or be remodelled by the hand of the workman. But *living* bodies, whether vegetable or animal, possess, as we have seen, the characteristic of being able to repair their own waste, and add to their own substance; and the possession of such a power is essential to their very existence. If the sunflower, which in fine weather exhales thirty ounces of fluid between sunrise and sunset, contained no provision within its own structure for repairing this enormous waste, it would necessarily shrivel and die within a few hours, as it actually does when plucked up by the roots. In like manner, if man, whose system throws out every day five or six pounds of waste matter by the ordinary channels of excretion, possessed no means of repairing the loss, his organism would speedily decay and perish. This very result is frequently witnessed in cases of shipwreck and other disasters, where, owing to the impossibility of obtaining food, death ensues from the body being gradually consumed in the act of carrying on the operations of life. In some instances, this has even proceeded so far that three-fourths of the whole weight of the body have been lost before life became extinct.

Here, however, the term *waste*, as applied to vegetables, is not employed in the same strict sense as when applied to animals. Correctly speaking, the exhalation from living plants is not actual waste of substance. The solid vegetable fibre, when once formed, is neither changed nor renewed like the tissue of an animal organ. Hence, a tree once fully developed, may, from subsequent want of nourishment, cease to grow, or actually die; but it will neither shrink in size nor waste away, as an animal does when deprived of food. A tree never becomes thin, as animals do, from disease or mismanagement. Its substance, once formed, remains undiminished while life continues; and its decay dates only from the period of its death, when the ordinary chemical laws resume the ascendancy. The exhalation from the sunflower, then, is not waste in the true sense of the word, but the escape of water absorbed from the soil or air. But as, in the vegetable world, every leaf of a tree is incessantly pouring out some portion of its fluids, and every flower forming its own fruit and seed, speedily to be separated from, and lost to its parent stem, and as the ordinary exhalations from their surface present

many points of analogy with the waste which goes on in animals, we may, without impropriety, apply the same term to both, provided we bear in mind that, in animals, waste extends to the actual substance of the organs, and increases in exact proportion to the exercise of their various functions; whereas, in vegetables, the solid structure remains unchanged, and the exhaled fluids are derived from the external supplies afforded by the soil and the air in which they grow.

Waste being, in this sense, the never-failing accompaniment or condition of vital action, it follows that a supply of nourishment proportionate to that waste is indispensable for the maintenance of health and life. We find, accordingly, that Nature has specially provided for this necessity, and endowed both animals and vegetables with the power of obtaining and assimilating the food from which the requisite nourishment may be obtained. But while the end secured is the same in both, the means employed to effect it are widely different. This, indeed, might be expected, when we consider the very different circumstances in which animals and vegetables are intended to live, and which obviously render any great similarity in their mode of nourishment impossible. With few exceptions, animals can change their place at will; and when food fails them in one quarter, they can seek it in another. But vegetables grow, flourish, and die, chained to one spot of earth; they cannot wander in search of a new soil, or a purer air, when those in which they live become exhausted of nutriment. In accordance with these peculiarities, animals have the power of storing up, at one meal, aliment sufficient for some length of time; while plants have no power of providing beforehand for the wants of the morrow. Hence the necessity for that difference which we find in the nutritive apparatus of each. The vegetable, firmly rooted in its place, and deriving support, at every moment, from the soil and air with which it is continually in contact, has no use for a stomach in which to store up supplies for future use. With animals, however, it is far otherwise: in the very act of searching for food, they are compelled to frequent change of place; and without a stomach in which to store up a temporary supply, from which the system may be nourished even when in motion, they would be continually exposed to starvation and death. Instead of being rooted to the spot like plants, animals not only enjoy the privilege of locomotion, but are compelled to use it, and often to go to a distance, in search of food and shelter. Consequently, if their vessels of nutrition were, like those of plants, in direct communication with the external substances which afford them nourishment, these vessels would be liable to be torn asunder at every movement, and the animals must either die from starvation, or forego the exercise of the higher functions for which they were created. The necessity for a constant change of place being thus imposed on them, a difference in the mode of their nutrition became also indispensable. To enable them, in all situations, to maintain the requisite connexion with their food, they are provided with a receptacle or stomach, in which to store up supplies proportioned to their necessities and mode of life. In their change of place, they thus *carry along with them* nourishment adequate to their wants; and the small nutritive vessels imbibe their supplies from the internal surface of the stomach and bowels, with which the food is in contact; just as the roots or nutritive vessels of vegetables do from their contiguous soil. The possession of a stomach is, accordingly, a characteristic of the animal system as contrasted with that of vegetables; and, as already mentioned, it is found even in the lowest orders of zoophytes, which, in other respects, are so nearly allied to plants.

The objects of nutrition being to sustain the vital operations, to repair waste, and to furnish materials for the development of the body, that process always goes on most vigorously when the animal functions are most active, and growth and waste proceed with

the greatest rapidity—the condition of health being, of course, understood. Even in vegetables, this relation is distinctly observable. In spring and summer, when, under the stimulus of heat and light, vegetable life is most active, and when leaves, flowers, and fruit are to be formed and growth carried on, nourishment is largely drawn from the soil, and the elaboration and circulation of the sap are proportionally vigorous; whereas in winter, when the leaves and flowers have passed away, and vegetable life is in repose, little nourishment is needed, and the circulation of the sap is proportionally slow. In accordance with these facts, every one will recollect how freely a shrub or a tree bleeds, as it is called, when its bark is cut early in the season, and how dry it becomes on the approach of winter. It is the activity of the circulation in summer which renders the temporary suspension of the process by transplanting so generally fatal at that season; whereas, owing to the comparative sluggishness with which it is carried on in winter, its partial interruption is then attended with much less risk.

If waste, growth, and the activity of animal and vegetable life, were always uniform in amount, the same kind and quantity of nutriment would be required at all ages, times, and seasons, and the due regulation of diet would become comparatively easy and definite. But the reverse is the case; for, as we have already seen, a remarkable difference in the activity of these processes is observable at different times, even in vegetables; and, consequently, the nutriment which is perfectly sufficient to sustain life at one time, might prove either excessive or wholly inadequate at another, under, perhaps, opposite circumstances. Here, then, is an obvious necessity for some regulating power to preside over and proportion the supplies to the actual wants; and what that power is, we shall now shortly explain.

The great peculiarity by which animals are distinguished from vegetables, consists in the instincts and intelligence by which the former are impelled to use the requisite means for their own preservation, in whatever situation they may be placed; whereas the vegetable possesses no analogous powers, and has neitherinstincts nor intelligence. In accordance with this distinction, animals are entrusted, to a considerable extent, with the supply of their own wants. But plants have no such discretionary power: the quantity of nourishment which they imbibe depends entirely on the circumstances in which they are placed, and varies as these vary. When they are exposed, as in spring and summer, to the stimulus of heat and light, all their functions become excited; growth and the development of new parts are accelerated; and, consequently, a more abundant supply of nourishment becomes indispensable to their health and existence. To meet this demand, Nature sends the frequent rains which are so essential to their wellbeing; and if placed in a dry soil, incapable of affording a copious supply of sap, they speedily wither and die. Exposed to cold, on the other hand, and shaded from the light, their vitality is impaired, and the demand for nourishment greatly diminished. This is uniformly the case in winter; and many circumstances shew that the change is really owing to the causes mentioned above, and not to any thing inherent in the constitution of the vegetable itself, apart from these. In tropical climates, for example, where heat, light, and moisture abound, vegetable life is ever active, and the foliage ever thick and abundant; and even in our own northern region, we are able, by artificial heat, so far to anticipate the natural order of the seasons, as to obtain the ripened fruit of the vine in the very beginning of spring. The whole system of *forcing* vegetables and fruit, so generally resorted to for the early supply of our markets, is, in truth, founded on the principle we are now discussing: by the regulated application of heat, light, air, and moisture, we are able to hasten or to retard, to a very considerable extent, the ordinary stages of vegetable life. But to ensure success in our

operations, we must be careful to proportion the supply of nourishment to the state of the plant at the time. If, by the application of heat, we have stimulated it to premature growth and foliage, we must, at the same time, provide for it an adequate supply of food, otherwise its activity will exhaust itself, and induce premature decay. Hence the regular watering which greenhouse plants require. But if we lower the vitality and retard the progress of the plant by excluding heat and light, the same copious nourishment will not only be unnecessary, but probably do harm by inducing repletion and disease.

In vegetables, the absorption of food is thus regulated, not by any discretionary choice of the plant itself, but chiefly by the circumstances of heat, moisture, and light, under which it is placed, and by the consequent necessity which exists at the time for a larger or smaller supply of nourishment to carry on the various processes of vegetable life. According to this arrangement, nutrition is always most active when the greatest expenditure of material is taking place. When growth is going on rapidly, and the leaves are unfolding themselves, sap is sucked up from the earth in immense quantity; but when these processes are completed as summer advances, and hardly any fresh materials are required, except for the consolidation of the new growth and the supply of the loss by exhalation, a much smaller amount of nourishment suffices, and the sap no longer circulates in the same profusion. In autumn, again—when the fruit arrives at maturity, the leaves begin to drop off, and the activity of vegetable life suffers abatement—nutrition is reduced to its lowest ebb; and in this state it continues till the return of spring stimulates every organ to new action, and once more excites a demand for an increased supply. But at no time does the vegetable exercise any choice with respect to the kind or amount of the nourishment it shall receive. These depend wholly on causes over which it has neither power nor control.

In animals, however, the same absolute dependence upon external conditions for the proper regulation of their food would interfere in a great degree with the purposes for which they exist; and hence a different arrangement becomes indispensable for them. They, too, are placed in circumstances requiring, at different times, very different quantities of nourishment. But while the activity of vegetable life increases or diminishes by slow degrees, according to the gradual advance of the seasons, and the supplies of food vary in the same gradual manner, animals are subjected to much more violent transitions from inaction to extreme activity; and hence the supply of nutriment requires to vary much more rapidly and frequently than, in the ordinary course of nature, can ever occur in the vegetable world. Animals thus require to adapt their nutrition to the ever-varying demands made upon the system, and therefore stand in need of some provision—not wanted in the vegetable kingdom—to *compel attention when nourishment is necessary*, and to enable them always to *proportion the supply of food to the real wants of the body*. Not being, like vegetables, in constant connection with their aliment, they might suffer from starvation if they did not possess some contrivance to warn them in time when to seek and in what quantity to consume it. But against this inconvenience an effectual guard has been provided. By endowing animals with the sense of *Appetite*, or the sensations of *Hunger* and *Thirst* generally included under it, the Creator has given to animals a guide in every way adequate to the purpose.

The very possession of a stomach, indeed, into which food sufficient for a shorter or longer period can be introduced at one time, almost necessarily implies the co-existence of some watchful monitor, such as Appetite, to enforce attention to the wants of the system with an earnestness which it shall not be easy to resist. If this were not the case in man, for example—if he had no motive more imperative than reason to oblige him to take food at proper intervals—he would, from in-

dolence and thoughtlessness, or the pressure of other occupations, be as liable to incur the penalty of starvation without being previously aware of his danger, as he is to delay many other acts which he is conscious ought to be performed, but which, under the influence of pre-occupation or a procrastinating spirit, he nevertheless often leaves undone from day to day, or altogether neglects. But as the due nourishment of the body cannot be delayed without danger to health and life, the Creator, with that beneficence which distinguishes all His works, has not only provided an effectual safeguard, in the sensations of hunger and thirst, but moreover attached to their regulated gratification a degree of pleasure which never fails to insure attention to their demands, and which, in highly civilized communities, is apt to lead to excessive indulgence. Such being the important charge committed to the appetites of hunger and thirst, it will be proper to submit to the reader, before entering upon the consideration of the complicated process of digestion, a few remarks on their nature and uses.

CHAPTER II.

THE APPETITES OF HUNGER AND THIRST, AND THEIR USES.

Hunger and Thirst, what they are—Generally referred to the stomach and throat, but perceived by the brain—Proofs and illustrations—Exciting causes of hunger—Common theories unsatisfactory—Hunger sympathetic of the state of the body as well as of the stomach—Uses of appetite—Relation between waste and appetite—Its practical importance—Consequences of overlooking it illustrated by analogy of the whole animal kingdom—Disease from acting in opposition to this relation—Effect of exercise on appetite explained—Diseased appetite—Thirst—Seat of Thirst—Circumstances in which it is most felt—Extraordinary effects of injection of water into the veins in cholera—Uses of thirst, and rules for gratifying it.

If, then, as I have attempted to shew in the preceding chapter, the sense of appetite be given to animals for the express purpose of warning them when a fresh supply of aliment is needed; and if it be true that waste goes on with a rapidity proportioned to the amount of bodily activity; it follows that, in the state of health (which is always implied in these pages, unless otherwise expressed), the dictates of appetite will also vary according to the mode of life and wants of the system, and, when fairly consulted, will be sufficient to direct us both at what time and in what quantity we ought to take in either solid or liquid sustenance. Such, accordingly, is the fact; but that we may read aright the intimations of appetite, it will be proper to add a few words of explanation regarding its seat, nature, and uses.

In popular opinion, the feeling of hunger is always referred to the stomach, and that of thirst to the upper part of the throat and back of the mouth; but, although a certain condition of the stomach and throat tends to produce them, the sensations themselves, like all other mental affections and emotions, have their seat in the brain, to which a sense of the condition of the stomach is conveyed through the medium of the nerves. In this respect, Appetite resembles the senses of Seeing, Hearing, and Feeling; and no greater difficulty attends the explanation of the one than of the others. Thus, the cause which excites the sensation of colour, is certain rays of light striking upon the nerve of the eye; and the cause which excites the perception of sound, is the atmospherical vibrations striking upon the nerve of the ear; but the consciousness of the sensations themselves takes place in the brain, to which, as the organ of the mind, the respective impressions are conveyed. In like manner, the cause which excites appetite is an impression made on the nerves of the stomach by the state of the system at large as represented by its nerves; but the feeling itself is experienced in the brain, to which that impression is conveyed. Accordingly, just as, in health, no sound is ever heard except when the external vibrating atmosphere has actually impressed the ear, and no colour is perceived unless an object be presented to the eye,—so appetite is never felt, except where, from the expenditure of the system, the stomach

is in that state which forms the proper stimulus to its nerves, and where the communication between it and the brain, for the due transmission of the impression to the seat of consciousness, is left free and unobstructed.

But as, in certain morbid states of the brain and nerves, unreal voices and sounds are heard, or unreal colours and objects are seen, when no external cause is present to act upon the ear or the eye,—so, in disease, a craving is often felt when no real want of food exists, and where, consequently, indulgence in eating can be productive of nothing but mischief. Such an aberration is common in nervous and mental diseases, and not unfrequently adds greatly to their severity and obstinacy. In indolent unemployed persons, who spend their days in meditating on their own feelings, this craving is very common, and from being regarded and indulged as if it were healthy appetite, is productive of many dyspeptic affections.*

If the correctness of the preceding explanation of the sensation of hunger be thought to stand in need of confirmation, I would refer to the experiments of Brachet of Lyons, as bearing directly upon the question. Brachet starved a dog for twenty-four hours, till it became ravenously hungry, after which he divided the nerves which convey to the brain a sense of the condition of the stomach. He then placed food within its reach, but the animal, *which a moment before was impatient to be fed, went and lay quietly down, as if hunger had never been experienced.* When meat was brought close to it, it began to eat; and, apparently from having no longer any consciousness of the state of its stomach—whether it was full or empty—continued to eat till both it and the gullet were inordinately distended. In this, however, the dog was probably impelled by the gratification of the sense of taste; for on removing the food at the beginning of the experiment to the distance of even a few inches, it looked on with indifference, and made no attempt either to follow the dish, or to prevent its removal.*

I may here, however, take the opportunity of observing, that implicit reliance can seldom be placed upon the conclusions drawn from experiments of vivisection, or operations on living animals; and it may not unreasonably be objected to these experiments of Brachet, that *any* operation upon an animal, involving the division of deep-seated and important parts, must give such a shock to the system, as to invalidate the conclusions drawn from the phenomena that ensue. Accordingly, we find other experimenters maintaining that the division of any important nerve (for instance the sciatic, which supplies the lower extremity), for a time destroys digestion. The dependence of the feeling of hunger upon the state of the nervous system, is indeed sufficiently proved by daily experience, without our having recourse to vivisection. The motion of a ship or of a swing, by affecting the brain, destroys the appetite of those not accustomed to it; and narcotics are frequently resorted to by savages to deaden the pangs of hunger. Brachet was of opinion, from some of his experiments, that when narcotics, such as opium, are introduced into the stomach, they produce their immediate effect by their action being transmitted to the brain through the nerves, before the drug has time to be absorbed by the vessels of the stomach, and to reach the brain through the medium of the circulating blood. He selected two dogs of the same size, and divided in one the nerves of communication with the brain, leaving them in the other untouched. Six grains of opium were then given to each at the same time, and the narcotic effect, he says, began immediately to manifest itself in the sound dog, while the other continued for a long time without any unusual appearance. Numerous and incontrovertible experiments, however, have established the fact, that the nerves have no power to convey a poisonous action, but that poisons in-

* Dyspepsia (from the Greek words δυς, *dys*, bad, and πεπτω, *pepto*, I concoct) is synonymous with indigestion.

* Brachet, Recherches Experimentales sur les Fonctions du Système Nerveux Ganglionaire, chap. iii. Paris edition.

variably act upon the system through the medium of the circulation; and Brachet's theory has lately been disproved by Müller and Wernscheidt, who repeated his experiments without finding any difference in the periods required for the action of opium on a sound animal, and on one whose nerves are divided.* Opium may, indeed, have a local narcotic effect upon the extreme branches of the gastric nerves, precisely as belladonna, when applied to the eye, exercises a local effect upon the nerves of the iris; but this action is essentially local, and does not extend beyond the immediate nerves to which the narcotic has been applied. The action of narcotics in removing hunger, admits therefore of a twofold explanation. It is possible that their local action upon the gastric nerves may remove that condition which, by the help of the brain, produces the sensation of hunger; but the opinion generally entertained is, that they act by affecting the nervous system through the medium of the blood. It is a common practice among the Turks to use opium for abating the pangs of hunger; and the drug not only performs this office, but, by its stimulating properties, excites the system, and gives rise to a degree of artificial strength which for a time replaces that which ought legitimately to have been derived from food. Tobacco, which our sailors are in the habit of using for a similar purpose, is more purely sedative, and its depressing action upon the system must be well known to all who, not being accustomed to its use, have ever tried its effects.

The relation thus shewn to subsist between the stomach and the brain, enables us, in some measure, to understand the influence which strong mental emotions and earnest intellectual occupation exert over the appetite. A man in perfect health, sitting down to table with an excellent appetite, receives a letter announcing an unexpected calamity, and instantly turns away with loathing from the food which, a moment before, he was prepared to eat with relish; while another, who, under the fear of some misfortune, comes to table indifferent about food, will eat with great zest on his "mind being relieved," as the phrase goes, by the receipt of pleasing intelligence. Excessive and absorbing emotion, even of a joyful kind, has also a disturbing effect. Captain Back tells us, in the interesting narrative of his last journey, that when he first heard of Captain Ross's return, "the thought of so wonderful a preservation overpowered, for a time, the common occurrences of life. *We had but just sat down to breakfast, but our appetite was gone,* and the day passed in a feverish state of excitement." (P. 245.) In such cases, no one will imagine that the external cause destroys appetite otherwise than through the medium of the brain. Indeed, the aversion to food occasionally amounts to a feeling of loathing and disgust, and even induces sickness and vomiting—a result which depends so entirely on the state of the brain, that it is often excited by mechanical injuries of that organ.

The analogy between the external senses and the appetite is, in various respects, very close. If we are wrapt in study, or intent on any scheme, we become insensible to impressions made on the ear or eye. A clock may strike, or a person enter the room, without our being aware of either event. The same is the case with the desire for food. When the mind is deeply engaged, the wants of the system are unperceived and unattended to—as was well exemplified in the instance of Sir Isaac Newton, who, from seeing the bones of a chicken lying before him, fancied that he had already dined, whereas in reality he had eaten nothing for many hours. Herodotus ascribes to mental occupation so much efficacy in deadening the sense of hunger, that he speaks of the inhabitants of Lydia having successfully had recourse to gaming as a partial substitute for food, during a famine of many years' continuance. In this account there is, of course, some exaggeration; but it affords a good illustration of the principle under discussion.

* Müller's Physiology. French ed., vol. i., p. 547.

The relation between the natural dictates of appetite and the actual wants of the system, is clearly shewn in the uniform increase of appetite consequent on healthy and vigorous exertion. If we indulge in free and active exercise in the open air, and thereby give rise to a good deal of waste by perspiration and exhalation from the lungs, the appetite becomes keener, and more urgent for immediate gratification; and if it is indulged after a sufficient interval of repose, we eat with a relish unknown on other occasions, and experience a sensation of *bien-être* or internal comfort pervading the frame, as if every part of the body were imbued with a feeling of contentment and satisfaction, the very opposite of the restless discomfort and depression which come upon us and extend over the whole system, when appetite is disappointed. An amusing example of the principle here inculcated is to be found in the *Correspondance Inédite de Madame du Deffand*,* where she describes her friend Madame de Pequigni as an insatiable, bustling, little woman, who consumes two hours every day in devouring her dinner, and "*eats like a wolf.*" But then, remarks Madame du Deffand, by way of explanation, "*It is true she takes a furious amount of exercise.*"

There is, then, an obvious and active sympathy between the condition and bearing of the stomach and those of every part of the animal frame; in virtue of which, hunger is felt very keenly when the general system stands in urgent need of repair, and very moderately when little waste has been suffered. This principle is strikingly illustrated during recovery from a severe illness. "In convalescence from an acute disease," as is well remarked by Brachet, "the stomach digests vigorously, and yet the individual is always hungry. This happens because all the wasted organs and tissues demand the means of repair, and demand them from the stomach, which has the charge of sending them; and, therefore, they keep up in it the continual sensation of want, which, however, is, in this case, only sympathetic of the state of the body."* In reference to this subject, Blaine observes, that "Hunger and thirst can only be satisfactorily explained by considering them as properties in the stomach, by which it sympathizes with the wants of the constitution; and hence it is, that food taken in invigorates, even before it can be digested."† Hence also the prostration of strength that is felt when the stomach has been for some time empty.

This sympathy is sometimes singularly manifest in disease. In some cases of affection of the mesenteric glands, for example, where stomachic digestion remains for a time pretty healthy, and the general system suffers chiefly from the want of nourishment caused by obstruction of the passage of the chyle into the blood, the appetite continues as keen and often keener than before. This happens because, the system being in want of nourishment, and the stomach healthy, all the exciting causes of hunger continue to act as before; and, accordingly, when food is taken, it is digested there as usual, but the chyle which is formed from it in the intestine can no longer be transmitted through the swollen glands in the usual healthy manner, to be converted into nutritive blood in the lungs—and the system thus failing to receive the required supply, recommences its cravings almost as if no food had been eaten. When the disease has advanced a certain length, however, fever springs up, and destroys both appetite and digestion.

The effects of exercise, also, shew very clearly the connection between appetite and the state of the system. If we merely saunter out without being actively enough engaged to cause a waste of tissues and induce increased exhalation from the skin and lungs, scarcely any change of feeling or condition ensues; whereas, if we exert ourselves sufficiently to give a general impetus to the circulation, and bring out moderate perspiration, but not to

* Vol. iii., p. 40. Paris, 1809.

* Recherches Experimentales, &c., p. 181.
† Blaine's Outlines of the Veterinary Art, third edition, p. 273.

induce fatigue, we feel a lightness and energy of a very pleasurable description, and generally accompanied by a strong desire for food. Hence the keen relish with which the fox-hunter sits down to table after a successful chase.

This intimate communion between the state of the system and that of the stomach, is a beautiful provision of Nature, and is one of the causes of the ready sympathy which has often been remarked as existing between the stomach and all the other organs; in other words, of the readiness with which they accompany it in its departure from health, and the corresponding aptitude of *their* disorders to produce derangement of the digestive function. Apparently for the purpose, among others, of establishing this sympathy, the stomach is supplied with a profusion of nervous filaments, which connect it with all the other vital organs, and thus explain the severe and often suddenly fatal effect of a heavy blow on the pit of the stomach, especially when distended with food.

Various attempts have been made to determine what the precise condition of the nerves of the stomach is, which, when intimated to the brain, excites the sensation of appetite; but without much success. By many, the pneumogastric nerve is regarded as the medium of communication between the stomach and the brain; but Dr John Reid has endeavoured to shew that the sensations of hunger and thirst are not destroyed by the section of that nerve, and, consequently, that at least it cannot be the sole medium of the sympathy alluded to. We have already spoken of the uncertainty which attaches to the conclusions drawn from vivisection; but, fortunately, we need not occupy our space by endeavouring to reconcile the statements of different experimenters, as it will be sufficient for all practical purposes, if the reader, without embarrassing himself with details of a still doubtful nature, will keep in mind, first, *that there is a direct sympathy between the stomach and the rest of the body*, by means of which the stimulus of hunger becomes unusually urgent where the bodily waste has been great, although a comparatively short time may have elapsed since the preceding meal; and, secondly, *that the co-operation of the nervous system is essential* to the excitation of that sympathy, and to the existence of appetite as an instinctive impulse.

Appetite, then, being given for the express purpose of warning us when a supply of food is necessary, of course its call will be experienced in the highest intensity when waste and growth —or, in other words, the operations which demand supplies of fresh materials—are most active; and in the lowest intensity when, from indolence and the cessation of growth, the demand is least. In youth, accordingly, when bodily activity is very great, and a liberal supply of nourishment is required both to repair waste and to carry on growth, the appetite is keener and less discriminating than at any other period of life; and, what is worthy of remark as another admirable instance of adaptation, *digestion is proportionally vigorous and rapid*, and abstinence is borne with great difficulty: whereas, in mature age, when growth is finished, and the mode of life more sedentary, the same abundance of aliment is no longer needed, the appetite becomes less keen and more select in its choice, and digestion loses something of the resistless power which generally distinguishes it in early youth. Articles of food which were once digested with ease, are now burdensome to the stomach, and, if not altogether rejected, are disposed of with a degree of labour and difficulty that was formerly unknown. Abstinence, also, is now more easily supported.

Appetite, it ought to be observed, may, like other sensations, be educated or trained to considerable deviations from the ordinary standard of quantity and quality, and this obviously for the purpose of enabling man to live in different climates and under different circumstances, and avoid being fixed down to one spot and to one occupation. In civilized life, however, we are accustomed to take undue advan-

tage of this capability, by training the appetite to desire a greater quantity of food than the wants of the system require, and stimulating its cravings by a system of cookery little in harmony with the intentions of Nature. This, however, is evidently an abuse of appetite, and no argument whatever against the sufficiency of its *natural* indications to lead us right.

But the most common source of the errors into which we are apt to fall in taking appetite as our only guide, is unquestionably the *confounding of appetite with taste*, and continuing to eat for the gratification of the latter long after the former is satisfied; just as the dog already mentioned ate till the œsophagus was distended, although it did not experience the slightest sensation of hunger.* In fact, much of the science of a skilful cook is expended in producing this willing mistake on our part; and he is considered decidedly the best *artiste* whose dishes shall recommend themselves most irresistibly to the callous palate of the gourmand, and excite on it such a sensation as shall at least remind him of the enviable excellence of a natural appetite. If we were willing to limit the office of taste to its proper sphere, and to cease eating when appetite expresses content, indigestion would be a much rarer occurrence in civilized communities than it is observed to be.

Viewed, then, in its proper light, appetite is to be regarded as kindly implanted in our nature for the express end of proportioning the supply of nourishment to the wants of the system; and if ever it misleads us, the fault is not in its inherent unfitness for its object, but in the artificial training which it receives at our own hands, and in our habitual neglect of its dictates. When we attend to its real indications, we eat moderately, and at such intervals of time as the previous exercise and other circumstances render necessary; and in so doing, we reap a reward in the daily enjoyment of the pleasure which attends the gratification of healthy appetite. But if we err, either by neglecting the timely warning which it gives, or by eating more than the system requires, mischief is sure to follow. In the former case, waste continues to make progress till the body becomes exhausted; and in almost exact proportion do the cravings of appetite become more and more intense, till they pass into those of uncontrollable *hunger*, which overthrows all obstacles, and seeks gratification at the risk of life itself. In the latter case, indigestion, gloomy depression, and repletion with its concomitant evils, make their appearance, and either embitter or cut short existence.

The general considerations which I have just submitted to the reader on the subject of the appetite for food apply so closely to the sensation of *Thirst*, that I need offer only a few remarks in regard to it.

Thirst is generally said to have its seat in the back of the mouth and throat; but the condition of these parts is merely a local accompaniment or indication of a want experienced by the whole frame. This is clearly proved by the fact, that, while local applications afford only momentary relief, the introduction of fluids into the system by any other channel—by immersion in a bath, by injection into the veins, or through an external opening into the stomach—is sufficient to quench thirst without the liquid ever touching the throat. If the mere dryness of the throat were the cause of thirst, the reverse of this would hold good, and more permanent relief be obtained from the local contact of water, than from its introduction into the system.

Thirst is experienced in its greatest intensity when the secretion, exhalation, and evaporation of the animal fluids are most active; and it is, consequently, most urgent in summer, in warm climates, and among persons engaged in severe exertion, particularly if exposed at the same time to the rapid evaporation caused by a dry and heated atmosphere. Blacksmiths, glass-blowers, engineers, and others, whose employment exposes them to the heat of furnaces, and in whom perspiration

* See p. 7.

is excessive, are accordingly almost constantly under the influence of thirst; whereas those who are employed in professions requiring only moderate exertion in a temperate atmosphere, and in whom the fluid secretions are very moderate, rarely experience the sensation in an urgent degree. For the same reason, great loss of blood induces excessive and intolerable thirst; and the generous self-denial of him who, in the battle-field, passed the cup to his wounded neighbour without stopping even to moisten his own lips, can be fully appreciated only by those who have themselves experienced the urgency of thirst in similar circumstances.

Thirst varies in intensity also according to the nature of the food. If the diet be of a hot and stimulating quality, such as results from a free admixture of spices, the desire for liquids is greatly increased. The same thing happens if the food be dry and solid. The purpose of the increased thirst in the former circumstances is manifestly to dilute and diminish the irritation of the stimulant, and thereby prevent the injury which it would otherwise inflict. The same principle explains the thirst experienced by those who drink too much wine. In instances of this kind I have heard great thirst in the evening and during the night complained of as habitual, without the persons even suspecting that it was owing to the wine; and yet, on abstaining from the latter, their thirst very soon disappeared. Thirst is produced by dry food, because a certain amount of liquid being necessary for digestion, if this be not present in the food itself, it is withdrawn from the blood, in the mouth and stomach, by means of the saliva and gastric juice; and hence, the necessity of replacing this fluid gives rise to the sensation of thirst. Salt food produces thirst in a twofold way; *first*, by its stimulating properties, whereby the exhalations of the skin are increased; and, *secondly*, by the power which a saline solution has of attracting the water of the blood, on the principle of exosmosis, as explained in Chapter VI.

Continued thirst, it is well known, is much more intolerable than continued hunger. The mass of circulating fluid in the body is very great, and, as the various excretions consist chiefly of fluid matter, it necessarily happens that when these have been eliminated for a considerable time without any liquid being received into the system, the proportion of solid matter in the body becomes unduly large. The blood, consequently, becomes thicker and changed in quality, and much more irritating than in its natural state. The craving of thirst is thus generally rendered more urgent and overpowering than that of hunger.

In Asiatic cholera, the watery portion of the blood, on which its fluidity depends, is drained off with great rapidity; and the result is, in the first place, an almost complete stoppage of the circulation, and, in the second, a constant craving for drink to supply the place of the lost serum, which consists chiefly of water holding some of the alkaline salts in solution. This circumstance explains, in some degree, the extraordinary effects which have been produced, even in the worst stages of the disease when life seemed almost extinct, by injecting large quantities of saline solutions into the veins. Patients apparently on the verge of existence, cold, pulseless, and inanimate, have, in the course of a few minutes, been enabled by this means to sit up in bed, and to exhibit, for the moment, all the signs of restored strength and health. The effect, however, was as evanescent as it was striking, and not one of the patients so treated ultimately recovered.

Fluids taken into the stomach, it is proper to observe, are not subjected to the slow process of digestion, but are absorbed *directly* into the system; so that, when we take a moderate draught, the whole of it is imbibed from the stomach in a very few minutes. Keeping in view this fact, and the above striking illustration of the influence of the condition of the blood upon the body at large, we can easily conceive why, in a state of exhaustion from abstinence, drink should be more

speedily restorative and refreshing than food.

Thirst is intended to direct us when and in what quantity we ought to drink; and so long as we lead a life of ordinary health and activity, and confine ourselves to the fluids with which nature provides us, there is little chance of our going far wrong by listening to its calls. But when we become indolent and dyspeptic, or resort to the use of fermented and stimulating liquors, which excite a thirst not recognised by Nature, the principle ceases to apply. At present, however, my observations refer only to simple drinks, such as water, and to the state of health; and I shall touch upon other liquids when treating of diet, in a subsequent part of the volume. Many persons, without experiencing any real thirst, habitually indulge in potations of water or beer at all hours of the day, and to an extraordinary extent, and feel unhappy when suddenly restricted in the indulgence. But this temporary discomfort ought not to be considered as indicating that these potations are really necessary; because the same result happens in the analogous instances of smoking or snuffing. All three are abuses and perversions of nature; and the uneasiness attending the sudden cessation of the beer or water drinking is no more a proof of either fluid being required, than that consequent on giving up cigar-smoking is an indication that Nature designed the lungs for the reception of the impure effluvia of the tobacco leaf instead of the fresh breezes of heaven.

CHAPTER III.

GENERAL QUALITIES OF FOOD.

Chemical composition of the animal body—Its materials undergo a constant expenditure during every vital action, and in the lungs—Food must therefore contain the substances necessary for the repair of this expenditure—and must be soluble in the gastric juice—Division of food into nitrogenous and non-nitrogenous; the former supplying materials for restoring to the tissues what they have lost during vital action, and the latter furnishing materials for respiration—Nitrogenous articles of food comprise what are called protein compounds, namely fibrin, albumen, and casein—Composition of these—Non-nitrogenous aliments are needed only for the support of animal heat—Manner in which this end is accomplished—This class of aliments comprises the hydrates of carbon, namely starch, sugar, gum, &c.—All substances necessary for nutrition are contained in milk—Dr Prout's consequent division of food into albuminous, saccharine, and oily—Digestion defined.

HAVING seen that the needful supply of nourishment is regularly demanded by the appetite, we shall now direct the reader's attention to a few of the general qualities of food, previous to entering upon the description of the organs of digestion; reserving till a later period the remarks we shall offer on the individual articles of diet.

Food, in order to be nourishing, must contain a large amount of digestible organic compounds, a smaller proportion of inorganic salts, and a certain quantity of water. The animal body contains nitrogen, carbon, oxygen, and hydrogen, in great abundance, along with small quantities of chlorine, sulphur, phosphorus, potash, soda, lime, magnesia, and iron, and occasionally also minute proportions of silica, fluor, manganese, and copper. All vital action is accompanied by a certain expenditure of these substances, which are accordingly found in the excretions of the body. The lungs give off a large proportion of the carbon and hydrogen; the kidneys almost the whole of the nitrogen, together with a large proportion of the inorganic salts; while the alvine evacuations contain a mixture of carbon, nitrogen, and inorganic matter. To be permanently nutritious, therefore, the food *must yield such an amount of carbon, nitrogen, water (oxide of hydrogen), and inorganic salts, as is necessary to repair the waste of the body.* If this condition be not fulfilled, the excretions will carry off more matter than is supplied to the system, and nutrition must of necessity be impaired.

An essential requisite of all aliment is *capability of solution in the gastric or stomach juice.* No substance can afford nourishment without entering the blood, which is the medium through which the nutritious particles are distributed to every part of the body; and none can be taken up by the absorbents

or the bloodvessels, except in a state of solution.

But all organic bodies which are received into the system do not afford nourishment in like manner or in equal degree. Two vital processes are constantly at work, requiring supplies of suitable aliment for their support: these are, *the waste of the tissues*, on which all vital action depends; and *the function of respiration*, which is necessary for the support of the temperature of the body. The first is accompanied by a great expenditure of nitrogen, which is thrown out of the system by the kidneys; and the second by a large consumption of carbon, which appears in the exhalations from the lungs. Food, therefore, naturally falls into two great divisions—NITROGENOUS and NON-NITROGENOUS articles of diet—according as it is subservient to the repair of the tissues, or to the supply of material for respiration. The nitrogenous division comprises all animal food except fat, and many articles derived from the vegetable kingdom; the non-nitrogenous comprises fat and oils, starch, sugar, gum, and similar allied substances. Chemical analysis has shewn that great similarity of composition exists between *fibrin*, the principal component part of flesh, *albumen* or white of egg, and *casein* or curd of milk; and Mulder has advanced the theory that all these substances are composed of one organic base, which he has named *Protein*, and which, according to his analysis, consists of carbon 54·54, hydrogen 6·99, nitrogen 16·01, oxygen 22·46, along with a quantity of sulphur, to the varying proportion of which he attributes the different qualities of the three substances above named. Later investigations have, however, shaken this theory, and the existence of protein itself, as a definite compound, is more than doubtful; still, as the term is a convenient one, we shall adopt it, and under the phrase "protein compounds" shall include the allied substances of fibrin, albumen, and casein, whether they are derived from the animal or vegetable kingdom. These substances, when treated with acids, form similar solutions; and their affinity will be apparent from the following table, which exhibits the proportions of the elementary substances composing them, as determined by the experiments of Dumas.

	Carbon.	Hydrogen.	Nitrogen.	Oxygen, &c.
Animal fibrin, ...	52·5	7·	16·5	24·
Vegetable fibrin, ...	53·23	7·01	16·41	23·35
Albumen (white of egg),	53·14	7·10	15·77	23·99
Vegetable albumen, . .	53·74	7·11	15·65	23·50
Casein of cow, ...	53·50	7·05	15·77	23·68
Vegetable casein, . . .	53·46	7·13	16·04	23·37

It is thus evident, that, in applying the term "protein compounds" to these bodies, we are including under the same category substances nearly identical in chemical composition, and which indeed, under the action of the gastric juice in the stomach, form solutions possessing identical qualities.

The chief use of the protein compounds in diet is, as already observed, to repair the waste which the tissues are constantly undergoing; but we shall afterwards see that, from the carbon which they contain, they may also be subservient to the purposes of respiration. The other great class of alimentary substances contain no nitrogen, and therefore cannot be of any service in repairing the waste of the tissues. Their sole use is to support, by their combustion in the system, the heat of the animal body, and on this account they have received the name of the aliment of respiration. They

comprise the *hydrates of carbon* (that is, compounds of carbon with oxygen and hydrogen, in the proportion to form water) *and fat*. The oxygen which is inhaled in respiration is absorbed into the blood, and there meets with the principles which have resulted from the assimilation of these bodies. It enters into chemical combination with them; a process of slow combustion takes place, during which heat is evolved; and the resulting carbonic acid is found in the expired air. The hydrates of carbon are very widely diffused throughout the vegetable kingdom; they comprise starch, sugar, gum, and other allied bodies, which, like the protein compounds, readily form identical solutions, either by means of chemical agents out of the body, or by the action of the animal fluids in the stomach and intestines during the process of digestion.*

In milk, we find a natural combination of all the substances necessary for permanent nutrition; and by the consideration of this fluid, Dr Prout was led to divide food into the three natural orders of the albuminous, saccharine, and oily. The first is typified in the curd, the second in the sugar of milk, and the third in the butter. Healthy milk, moreover, contains a sufficient quantity of inorganic salts to supply the materials of the bones.

DIGESTION is the process by which these various substances are dissolved and rendered fit for absorption by the vessels, and thus for becoming component parts of the body. In ordinary language it is spoken of as if it were confined to the stomach; but we shall see as we proceed, that the adoption of such a view would exclude the consideration of organs which perform an important part in the process. Strictly speaking, digestion commences as soon as the food enters the mouth, and ceases only with the expulsion of the fæces. The nutriment, as it traverses the alimentary canal, undergoes successive changes, dependent partly on its nature and partly on the functions of the different parts with which it comes in contact. The gastric juice is not of itself sufficient to insure proper digestion, but requires the assistance, in a greater or less degree, of the saliva, bile, and pancreatic juice. To the operation of these fluids, the attention of the reader will be directed in the subsequent chapters.

* Ligneous fibre, though allied in composition to many nutritive substances, resists the action of the gastric juice, and hence we find that the kernels of cherry and plum stones which have been swallowed, pass through the intestines unchanged, protected by their ligneous covering. Even grain, when whole, is protected by its husk, and passes unaltered through the body. On this fact depends the economy of crushing the corn of horses.

CHAPTER IV.

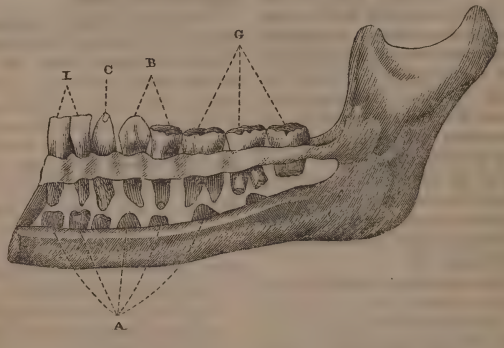
MASTICATION, INSALIVATION, AND DEGLUTITION.

Mastication—The Teeth—Teeth, being adapted to the kind of food, vary at different ages and in different animals—Teeth classed and described—Vitality of teeth, and its advantages—Causes of disease in teeth—Means of protection—Insalivation and its uses—Gratification of taste in mastication—Deglutition.

PRESUMING that the reader has derived from the preceding observations a sufficient knowledge of the general nature and uses of alimentary substances, we shall now proceed to consider in their due order the various stages of the function of digestion. The first important step in this complicated process is that by which the food, after being received into the mouth, is mixed with the saliva and broken down till it becomes of a uniform pulpy consistence, fitting it for being easily swallowed and acted upon by the gastric juice on its arrival in the stomach. The term *mastication* or *chewing* is used to denote this operation; and the chief instruments by which it is performed are the teeth, the jaws, the muscles which move the jaws, the tongue, and the salivary glands. On each of these we shall offer a few observations.

The TEETH differ in number and form according to the kind of food on which the animal is destined to live; but in man and the higher orders of animals they may be divided into three distinct groups:—1*st*, The *incisor* or *cutting* teeth, eight in number, or four in front of each jaw, and marked I in

the subjoined woodcut, which represents one-half of the lower jaw and consequently only one-fourth of the whole number of teeth. 2*d*, The four *cuspidati*, *canine*, or *dog* teeth (C in the woodcut), each being, as represented below, in contact with the outer incisor tooth, and called *canine* from being large in the dog and carnivorous animals, and used by them for the purpose of *seizing* and *tearing* their food. And, 3*d*, The *molares* or *grinders*, B G, twenty in number, situated at the back part of the jaw, and so called from their



office being to grind or bruise the food subjected to their action.*

In herbivorous animals, the canine teeth, for which they have no use, are comparatively undeveloped; whereas in carnivorous animals, which tear their prey in pieces, the canine teeth are large, powerful, and pointed, and the incisors comparatively small. In these animals they constitute what are properly called the *tusks*, and in some species are of a truly formidable character. The molar or grinding teeth differ, in like manner, according to the nature of the food. In herbivorous and granivorous animals they are large and powerful, and to increase their efficiency the lower jaw admits of considerable lateral motion in a horizontal direction; whereas, in carnivorous animals, it admits of motion only upwards and downwards, as in opening and shutting the mouth. The lateral grinding motion is very evident in *ruminating* animals, such as the cow, which, after having filled its stomach with provender, generally lies down to *ruminate*, or *chew the cud*, as it is called—the rumination consisting in bringing up small masses of herbage from the stomach, and submitting them to a thorough mastication or grinding between the molar teeth before being again swallowed and digested.

From this relation between the food and the organs of mastication, naturalists can tell with certainty, by simply inspecting the teeth, on what kind of food the animal to which they belong is intended to live; and as the teeth of man partake of the characters of those of both herbivorous and carnivorous animals, this is a strong indication that his diet was intended to be of a mixed kind, not confined exclusively to either the vegetable or the animal kingdom.

Hard and resisting as the teeth appear, they are nevertheless endowed with the same vital properties as other parts; and the root of each is perforated longitudinally by a small canal, through which the bloodvessels and nerve are admitted to its internal structure. From these bloodvessels the tooth derives its nourishment when growing; but afterwards they almost entirely disappear. From its nerve the tooth derives that sensibility which

* In Latin, *cuspis* signifies the point of a spear; *canis*, a dog; *molo*, a mill; *incisor*, any thing which cuts.

makes us instantly aware of the contact of bodies either too hot or too cold. When diseased, the ordinary sensibility of the nerve is often so far increased as to become converted into the racking pain of toothach.

To prevent the teeth from being worn down by friction, their visible part or crown is covered with a very hard white ivory-looking substance, called *enamel*, into which neither blood-vessels nor nerves have been observed to penetrate. Owing to this structure, the teeth can be safely exposed, on all proper occasions, without sustaining damage—a privilege on which most persons will be disposed to place a higher value, after having experienced the pains consequent upon injury of the nerve from a portion of the enamel being broken off.

An obvious advantage attending the vitality of the teeth is, that it enables them to accommodate themselves to the growth of the jaw and general system at the different periods of life. In early infancy, when the human being is designed to live exclusively on its mother's milk, for the disposal of which no teeth are required, the latter are still imperfectly formed, and entirely hidden in the jaw: it is only at the end of some months that the front or cutting teeth begin to appear; and the whole set of *milk, deciduous*, or *falling-out* teeth, twenty in number, is not completed till about or after the third year. In the course of three or four years more, however, growth has advanced so far that the first set of teeth no longer fill the jaw; and they soon begin to be displaced by the second or permanent set, the gradual development of which commences at that period of life, and is not finished till the appearance of the last four grinders or *wisdom-teeth*, about the age of maturity.

The teeth, being living parts, and at the same time endowed with a mechanical function, are liable to injury in both capacities. Being composed chiefly of earthy matter, such as phosphate and carbonate of lime, the contact of strong acids decomposes or destroys their substance, and leads to their rapid decay. Hence, the whiteness produced by acid tooth-powders and washes is not less deceitful than ruinous in its consequences; and hence, also, great caution is necessary never to allow the acid drops frequently prescribed by physicians to come into contact with the teeth.

The teeth, being constantly moistened with saliva, have a tendency to become incrusted with the tartar or earthy matter which it contains in solution, and which is separated from it partly by the evaporation of the more fluid constituents while breathing, and partly by chemical decomposition. As this incrustation not only destroys the beauty of the teeth, but also hastens their decay, it ought to be carefully removed as soon as formed; and the most effectual mode of doing so is to brush the teeth regularly twice a-day —especially in the morning, when the quantity is greatest—with a brush dipped in soft water—till every particle is removed. The addition of any soft impalpable powder will assist in the effect; but nothing capable of acting chemically on the teeth, or of injuring them by friction, ought ever to be resorted to. Washing the mouth after every meal is also a good preservative.

When a long time elapses without eating, and also when digestion is impaired, the quantity of tartar which accumulates on the teeth is very great. Hence they are always most incrusted in the morning, and during fevers and other affections when little or no food is taken. I have seen one instance in which a thick coat of tartar was removed by a dentist, in the belief that it was a diseased tooth—the tooth itself on which it was formed being left in the jaw perfectly sound.

When the tartar is not duly removed, its presence injures the teeth, irritates the gums, and generally leads, sooner or later, to considerable suffering. The regular washing and brushing above mentioned ought, therefore, to be sedulously practised at every period of life, and taught as a duty to the young. When digestion is very vigorous, the health good, and the diet plain and containing a full proportion

of vegetable matter, the deposition of tartar seems to be diminished, and the teeth preserve their natural colour. Many rustics and savages thus possess teeth, the whiteness of which would be envied by many women of fashion.

When indigestion is present, the mucous secretions in the mouth become altered in character, and by their incessant contact injure and even destroy the teeth. From this cause we often see the teeth, in young people, in a state of complete decay. They are, in reality, the subjects of chemical decomposition, and are eaten away by the morbid secretions of the mouth; and hence, in such cases, we generally find the individual complaining of heat and soreness of the tongue, gums, and mouth, and occasionally of the teeth being "set on edge."

When the digestion is healthy and vigorous, toothach is rarely experienced, unless it be in consequence of a chill. But even then, severe and continued pain is seldom felt if the stomach have been previously healthy.

Being endowed with life, the teeth require more care than if they were merely dead matter. One way in which they often suffer from our losing sight of their vitality, is the sudden changes of temperature to which they are recklessly exposed. Being, from their solidity, rapid conductors of heat, their internal nerve speedily becomes affected by the sudden alternations of temperature which they daily undergo, both in taking food and in the change from a warm to a cold atmosphere. It is in this way that toothach is so often excited by the common custom of taking a glass of cold wine or water immediately after finishing a plateful of very hot soup; and of taking tea and coffee, and every kind of meat, as hot as they can possibly be swallowed.

In passing from a warm to a cold atmosphere, it is, consequently, useful to protect the teeth from the influence of the sudden change, by breathing through a respirator, a woollen comforter, or two or three folds of a silk handkerchief. When the teeth and lower part of the face are left exposed during such transitions, rheumatism and toothach not unfrequently ensue, especially in delicate subjects, from the direct impression of the cold air upon parts rendered more susceptible by the preceding heat.

The great source of injury to the teeth, however, both in childhood and in mature age, is disordered digestion. If the health be good, and the stomach perform its functions with vigour, the teeth will resist much exposure without sustaining injury. But if these conditions fail, they will rarely continue long unscathed.

It is, therefore, almost always from disordered health that, in infancy, teething gives rise, as it often does, to serious constitutional disorder.

Something more, however, than the mere action of the teeth and jaws is required to prepare the morsel for being swallowed. If we attempt to chew a bit of dry biscuit or mealy potato, we encounter at first some difficulty, from the stiffness and dryness of the mass in the mouth, and feel instinctively that it would be in vain to attempt to swallow it until moistened either by the flow of saliva which occurs during mastication, or by the admixture of fluid from without. In ordinary states of the system, the supply of saliva proves sufficient for the purpose; and the process by which its due admixture with the contents of the mouth is accomplished is called the *insalivation* of the food: but when great thirst prevails, the flow of saliva proves insufficient, and then liquids must be taken before drier food can be either relished or swallowed.

To provide the necessary saliva, and to connect its supply directly with the process of mastication, to which it is subservient, several glands for its secretion have been placed in the immediate neighbourhood of the mouth, in such a way that the jaws cannot be opened and shut without affording them a stimulus, and still farther increasing the secretion which the presence of the morsel, or even the expectation of food, is itself sufficient to begin. From this arrangement it follows, that the more perfectly mastica-

tion is performed, the more thoroughly does the morsel become impregnated with the salivary fluid, and the better fitted is it rendered for subsequent deglutition and digestion.

Due mastication being thus essential to healthy digestion, the Creator, as if to insure its being adequately performed, has kindly so arranged, that the very act of mastication should lead to the gratification of taste, the mouth being the seat of that sensation. That this gratification of taste was intended, becomes obvious when we reflect, that, even in eating, Nature makes it our interest to give attention to the process in which we are for the time engaged. It is well known, for example, that when food is presented to a hungry man, whose mind is concentrated on the indulgence of his appetite, the saliva begins to flow unbidden, and what he eats is consumed with a peculiar relish, and is easily digested. Whereas, if food be presented to an individual who has fasted equally long, but whose soul is absorbed in some great undertaking or deep emotion, and who, consequently, is insensible to the gratification of taste, it will be swallowed almost without mastication and without sufficient admixture with the saliva—now deficient in quantity—and will lie on the stomach for hours unchanged. In this point of view the peculiarly English custom of reading the newspapers or magazines during breakfast is more hurtful than one would suppose, and many dyspeptics have been surprised at the benefit resulting from its discontinuance. However much, then, philosophy and morality may condemn the *undue* cultivation of our bodily appetites, it cannot be denied that a certain degree of attention to taste, and to the pleasures of appetite, is both reasonable and beneficial; and it is only when these are abused that we oppose the intentions of Nature.

From late investigations it appears probable that the saliva, besides supplying the food with the requisite moisture, acts a part in the chemical changes of the digestive process. When bread, for instance, is thoroughly mixed with saliva, and allowed to stand for some time, part of the starch which it contains is found to have been converted into sugar—a change which is supposed to be owing to a substance contained in the saliva, and which is analogous in its properties to *diastase*, the principle which in malt converts the starch into sugar. When saliva is filtered and mixed with six times its amount of absolute alcohol, a white precipitate separates after some time; which precipitate, according to Mialhe, consists of this animal diastase, and has the property of converting starch into dextrine (a sort of gum) and sugar.* The gastric juice possesses no similar property, but its presence does not seem to interfere with the action of the saliva, which again has no effect upon protein compounds. Its digestive powers appear to be limited to assisting in the solution and transmutation of farinaceous substances; and as these effects require some time for their manifestation, it is not till after the lapse of an hour or more that sugar can be detected in the stomach. We can now understand why mastication is of much more consequence in herbivorous than in carnivorous animals; for although farther investigation into the changes which saliva produces in the food is still requisite, enough is known to prove that its action is not simply mechanical.†

The salivary secretion is always most copious in those creatures whose food requires continued mastication. In ruminating animals, the salivary glands are not only numerous and of great size, but so situated that the play of the muscles in the act of rumination communicates to them a proportionate stimulus. In those animals, again, which do not masticate at all, but swallow their food entire, there is scarcely any salivary secretion, and the glands appropriated to it are very small. Birds, and many fishes and reptiles, belong to the latter class.

* Valentin's Lehrbuch der Physiologie, 2d ed., vol. i., p. 306. Brunswick, 1847.

† Bread is more digestible when well fermented, than when it is pasty and heavy, and many persons find that when prepared with yeast, it digests more readily than when an acid and soda have been used. Previous fermentation probably facilitates the peculiar changes produced by the animal diastase.

According to Liebig, another use of mastication is the introduction of atmospheric air into the stomach by its admixture with the saliva in the shape of froth. Liebig contends that the oxygen of the air takes a share in digestion, and that the nitrogen thus set free in the stomach is exhaled by the lungs and skin. But I entirely agree with Blondlot in regarding this opinion as erroneous, and contradicted by experience. If we examine a morsel of bread, for example, when just ready for swallowing, so far from finding it porous or frothy, we find all its previously contained air expelled, and the morsel itself uniform in consistence, and divested of every appearance of air-bubbles. In like manner, when the stomach of an animal is opened soon after a full meal, we can detect no contained air in it, but only a dense mass of uniform consistence.

Besides acting as the organ of taste, the tongue is of essential use in forming the alimentary bolus, and in submitting it to the action of the teeth. It moreover executes admirably the duty of a watchful sentinel, by guarding against the passage of any thing likely to prove injurious, either chemically or mechanically, to the digestive organs. For this purpose, the tongue is most abundantly supplied with nerves, which not only confer upon it the sense of taste, but constitute it the finest organ of touch in the body. We all know how readily a hair or any similar intruding substance is detected in the mouth; and Weber has shewn that the tongue recognises two distinct sensations when the prongs of a pair of compasses, separated only by a distance of half a line, are applied to it—while a distance of a whole line is necessary to produce two sensations in the tips of the fingers, and as much as 30 lines in the skin of the back. Hence it appears that the tongue has double the tactile power of the fingers, and 60 times that of the skin of the back.

The morsel, duly prepared by thorough mastication and impregnation with saliva, is now ready for transmission to the stomach. To this part of the process the term *deglutition* or *swallowing* is applied.

Immediately at the back part of the mouth, three several passages present themselves, leading in different directions—one upwards and forwards into the nose, another downwards and in front into the windpipe, and a third downwards and behind into the *œsophagus*, *gullet*, or *meat-pipe*, and stomach. The last is the passage taken by the food; and the violent coughing and occasional suffocation induced when it accidentally passes into the windpipe, are but a specimen of the serious evils which would be continually occurring if some provision were not made to obviate the danger—while the rarity with which such accidents actually happen, proves the almost unfailing efficacy of that which has been devised.

The passage of the food into the nostrils is prevented by the action of the muscles of the fauces, which cause the posterior arches of the fauces, seen at the back of the throat beyond the tonsils, to approach each other like the scenes in a theatre, while the moveable fleshy curtain or valve hanging down from the palate, and visible at the back part of the mouth, is stretched backwards so as to extend to the back part of the throat, and thus entirely shut up the opening into the nostrils. The passage into the windpipe, again, is protected by a cartilaginous lid or covering called *epiglottis* (from επι, *epi*, upon, and γλωττις, *glottis*, the tongue), which projects backwards from the root of the tongue, and conducts the morsel, as by a slide, over the *glottis* or opening of the windpipe. The epiglottis, however, is greatly assisted in this operation by that rising upwards and forwards of the gullet and windpipe to meet the morsel, of which we are conscious, and which, in the act of swallowing, can easily be felt by the hand: its effect is in some degree to hide the glottis under the backward projection of the root of the tongue, and allow the morsel to drop past the windpipe into the gullet.

So soon, therefore, as the alimentary bolus is properly prepared, it is pushed backwards, between the tongue and

the palate, till it comes within the sphere of action of the muscles of the throat. These, by its contact, are stimulated to involuntary contraction, and the food passes beyond our control into the gullet, and thence into the stomach. The gullet is simply a round tube, made up of two rows of muscular or fleshy fibres, the one longitudinal and the other transverse and circular, with a soft, moist lining membrane to facilitate the transmission of its contents. When the morsel is introduced, its upper part contracts involuntarily, and pushes the mass downwards; the portion now reached contracts in its turn, and propels the morsel farther; and so on in succession till it arrives at the stomach.

Deglutition or *swallowing* is thus a more complicated operation than at first sight it appears to be. On looking at any person eating, one is apt to think that the morsel passes along the gullet into the stomach by its own weight; but we speedily perceive the error when we recollect that, in the horse and the cow for example, the mouth is on a level with the ground when feeding or drinking, and that the morsel or water is consequently propelled upwards into the stomach against its own gravity. It is well known, also, and often made a matter of public exhibition, that a man can swallow even liquids when standing on the crown of his head, with the natural position of the stomach reversed.

Deglutition is easier and quicker when the appetite is keen, and the alimentary bolus or morsel is moist and properly softened. It is slow and difficult when the morsel is dry and mealy, and the appetite nauseated. In vomiting, the action of the muscular fibres is *inverted*, or proceeds from the lower end of the gullet towards the mouth; and hence the object is carried upwards, instead of downwards as in the natural order.

CHAPTER V.

ORGANS OF DIGESTION—THE STOMACH—AND ITS STRUCTURE.

Surprising power of digestion—Variety of sources of food—All structures, however different, formed from the same blood—General view of digestion, chymification, chylification, sanguification, nutrition—The stomach in polypes, in quadrupeds, and in man—Its position, size, and complexity in different animals—Its structure; its peritoneal, muscular, and villous coats; and uses of each—Its nerves and bloodvessels, their nature, origins, and uses—The former the medium of communication between the brain and stomach—Their relation to undigested food—Animals not conscious of what goes on in the stomach—Advantages of this arrangement.

If, in the whole animal economy, where all is admirable, there be one operation which, on reflection, appears more wonderful than another, and which evinces, in a higher degree, the prodigious resources and power of the Creator in fashioning every thing to His own will, it is perhaps that process by which the same kind of nutriment is extracted from apparently the most opposite varieties of food consumed by living beings.

Remarkable, however, as this uniformity of result undoubtedly is, it becomes still more striking when we contemplate the variety of sources from which food is derived for the support of animal life. To use the words of a late popular writer, "There is no part of the organised structure of an animal or vegetable, however dense its texture or acrid its qualities, that may not, under certain circumstances, become the food of some species of insect, or contribute in some mode to the support of animal life. The more succulent parts of plants, such as the leaves or softer stems, are the principal sources of nourishment to the greater number of larger quadrupeds, to multitudes of insects, as well as to numerous tribes of other animals. Some plants are more particularly assigned as the appropriate nutriment of particular species, which would perish if these ceased to grow: thus the silkworm subsists almost exclusively upon the leaves of the mulberry-tree; and many species of caterpillars are attached each to a particular plant, which they prefer to all others. There are

at least fifty different species of insects that feed upon the common nettle; and plants of which the juices are most acrid and poisonous to the generality of animals, such as euphorbium, henbane, and nightshade, afford a wholesome and delicious food to others."* Nor are the precision and accuracy with which the same fluid—the blood—affords to every structure of the body the precise species of nourishment or secretion which its elementary composition requires, less admirable and extraordinary than its own original formation from such a variety of materials. To bone, the blood furnishes the elements of bone with unerring accuracy; to muscle the same blood furnishes the elements of muscle,—to nerves the elements of nerve,—to skin the elements of skin,—and to vessels the elements of vessels;—and yet, while each of these differs somewhat in composition from the others, the constituent elements of the blood by which they are furnished are everywhere the same.

Similar phenomena, indeed, occur in the vegetable world; but this, instead of diminishing our wonder, tends rather to augment it. The same elements, extracted from the same soil and the same atmosphere, are converted into every variety of vegetable product—into leaves of every shade of green, flowers of every form and tint, and juices of every quality, from the deadly poison up to bland and life-supporting milk. Nay, even in the same plant—as in the poppy—we sometimes find the seeds and the capsule which covers them endowed with the most opposite properties.

It would be very interesting to discover by what resources Nature thus effects the production of the same kind of nutritive elements from so great a variety of substances, and apportions to every part the precise constituents of which it stands in need; but although modern chemistry, and especially the researches of Liebig, Dumas, Boussingault, and other recent investigators, have thrown considerable light on the subject, the results at which these chemists have arrived are too abstruse, and would require too much detail, to admit of their proper introduction into a work so exclusively popular in its character as the present; and it will therefore be more advisable to confine our attention to those parts of the inquiry which have a direct practical bearing, and about which there is no difference of opinion. We know already that certain organs are concerned in the processes above mentioned, and that these organs act under the regulation of certain general laws. If we make ourselves acquainted with, and carefully conform to these laws, we shall reap a rich reward in the enjoyment of sound and vigorous digestion; whereas, if, either from ignorance or from carelessness, we fail to act in accordance with them, we shall bring upon ourselves severe suffering in the form of dyspeptic or nervous disease. Assuredly, then, alternatives like these ought to excite some desire for information in the minds even of the most indifferent.

That the reader may be better enabled to understand the meaning of various terms and expressions, the frequent use of which it is almost impossible to avoid, even in the beginning of our exposition, it will be useful, before commencing a description of the organs concerned in digestion, to take a general view of the different stages of preparation through which the food passes, between its reception into the stomach and its *assimilation*, or ultimate conversion into a constituent part of the animal body.

When the food, after being masticated, is received into the stomach, it is there subjected to the action of a solvent fluid, called the *gastric* or *stomach juice* (from γαστηρ, *gaster*, stomach), by which it is gradually converted into a soft greyish and pultaceous mass, called *chyme* (from χυμος, *chymos*, humour or juice); whence the process is called *chymification*, or *chyme-making*. That part of the chyme for which simple gastric digestion is sufficient, is at once absorbed by the blood-vessels and

* See Roget's Bridgewater Treatise, vol. ii. p. 59.

absorbents of the stomach; the remainder, which requires further digestion, is expelled by the contractile power of the muscular coat of the stomach into the first portion of the intestines, called the *duodenum* (from *duodenus*, consisting of twelve, because it is supposed to be about twelve inches long). It there meets with *bile* from the liver, and with the *pancreatic juice*, which very much resembles the saliva, and flows from the *pancreas* or *sweet-bread* (παν, *pan*, all, and κρεας, *kreas*, flesh, it being of a fleshy consistence), a large gland which lies across the spine a little below the stomach, and is marked PP in the woodcut given on page 39. By the action of these two fluids, the chyme is converted into a yellowish semifluid mass, from which the absorbents, which are extensively ramified on the inner membrane of the bowels, extract a milky-white fluid named *chyle* (from χυλος, *chylos*, chyle). This process is termed *chylification* or *chyle-making*; and the absorbent vessels are sometimes named, from the white colour of their contents, *lacteals* or *milk-bearers* (from *lac*, milk). These absorbents ultimately converge into one trunk, named the *thoracic duct* or *chest-pipe* (from its course lying through the *thorax* or *chest*), and which terminates, as will be seen in a cut on page 36, in the great vein under the clavicle or collar-bone, hence called *subclavian* vein, just before the latter reaches the right side of the heart; and there the chyle is poured into the general current of venous blood.

But although thus mingled with the blood, the chyle is not yet sufficiently capacitated for its duties in the system. To complete its preparation, it still requires to be exposed to the action of the air during respiration. This is, accordingly, done by its passing through the lungs along with the dark venous blood, which stands in need of the same change. In the course of this process, both the chyle and the venous blood are converted into red, arterial, or nutritive blood, which is afterwards distributed by the heart, through the arteries, to supply nourishment and support to every part of the body. Hence, the change which takes place in the lungs is properly enough named *sanguification* or *blood-making*.*

The thickish yellow residue which remains in the intestines after the separation of the chyle from the chyme, is that portion of the food which affords little or no nourishment, and which, after traversing the whole length of the intestinal canal, and undergoing still farther change, is thrown out of the body in the shape of *fæces* or excrement. But in this course its appearance is considerably altered, and it receives the addition of much waste matter, which, having already served its purposes in the system, is at last, as will be afterwards shewn, thrown out by the same channel.

With this general view of the nature of Digestion before us, we can now examine more satisfactorily the structure and mode of action of each of the organs concerned in effecting it. *Chymification* being the first step in the complicated process, we shall begin with the organ by which it is performed, namely, the STOMACH.

In man, the stomach is a large membranous and muscular bag, lying under the convex part of the lower ribs of the left side, and stretching over towards the right side. In shape it somewhat resembles the bag of a bagpipe, as will be seen from fig. 1, page 24, representing it as viewed in front. Its left or larger extremity B is in contact with the ribs, and its right or narrow extremity corresponds in situation to the hollow commonly called *the pit of the stomach*.

The position of the stomach, relatively to the chest, bowels, and liver, will be understood by inspecting fig. 2, page 24, on which it is marked *St^m*. It is separated from the cavity of the chest by the diaphragm or midriff DD, with which the left extremity of its upper surface is in immediate contact, and through which the gullet passes to enter that extremity. Its right or *pyloric* extremity, marked P in fig. 1, lies close to the lower surface of the liver (*Livr.* fig. 2.),

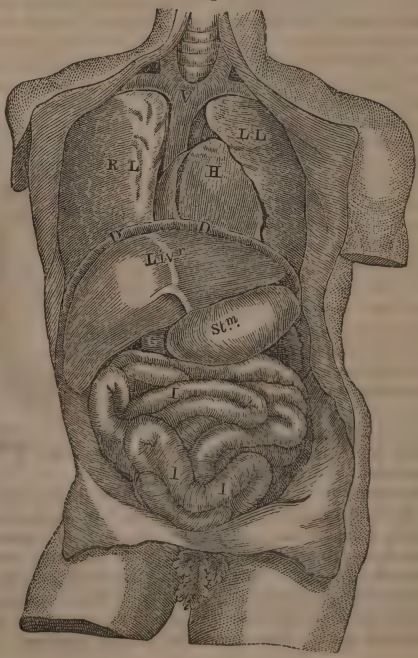
* For a full explanation of the nature, importance and laws of respiration, see the author's Principles of Physiology applied to Health, &c., chap. ix.

the latter being a little displaced to shew its situation. On the lower surface it has the appearance of resting on the intestines as if imbedded among their folds.

The parts of the stomach which have

Fig. 1.

Fig. 2.

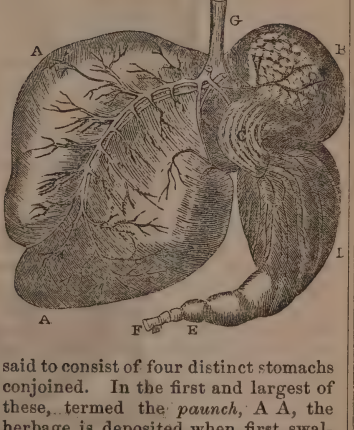


received names, and require to be noticed, are—the *cardiac* orifice, through which food is introduced, and which is marked C in figure 1, p. 24, and so named from being near the κηαρ, *kear*, or heart; P, the *pylorus*, or pyloric orifice (from πυλωρος, *pyloros*, a *gate-keeper*, because it was supposed to allow none but digested food to pass out), where the intestine called the *duodenum* begins, and through which the chyme passes from the stomach; SS, the *smaller arch or curvature*; and GG, the *greater arch or curvature*. The spleen is attached to that part of the larger arch marked with dotted points. From the situation of the cardia C, and its connexion with the gullet, it will be at once perceived that this forms one of the attachments by which the stomach is retained in its place.

In size the stomach varies much in different individuals, as well as in different animals, according to the bulk and quality of their food. As a general rule, it is larger among the labouring poor than among the rich, as the former require a larger quantity of their inferior food, to obtain from it a sufficient amount of nourishment. For a similar reason, animals which subsist on vegetable substances have a more capacious stomach than those which subsist on animal or concentrated food. In man, its capacity may be diminished or augmented within certain limits, by corresponding modifications of diet. In some gluttons, and in cases of diseased appetite, it has been found of enormous dimensions; but this rule does not always hold, for in some instances of immoderate eaters, the stomach is smaller than usual, and in them its contents pass through only partially digested.

In accordance with this relation between the capacity and structure of the organs of digestion, and the quality of the food, the stomach and intestines are found to be very small and short in carnivorous quadrupeds and birds of prey, which are intended to live on concentrated aliment. The same is the case with the granivorous or *grain-eating* birds, as their food also is contained in a small bulk. But in herbivorous animals—in the food of which the nutritive principle forms a very small proportion of the whole, perhaps not one-twentieth, and which consequently require a large bulk of it for their sustenance—the digestive apparatus is on a large scale, as any one may perceive in a moment, by comparing the portly protuberance of the cow with the lank paunch of the greyhound. The cow, in fact, is little else but a living laboratory for the conversion of vegetable into animal matter; and, accordingly, not only is its stomach large and complex, but its intestinal canal is nearly twenty-four times the length of its body; whereas in some carnivorous animals, the whole intestine does not exceed once their own length.

In ruminating animals, such as the sheep and ox, the stomach is not only large, to adapt it to the bulky nature of their food, but, as will be seen from the next figure, is complicated in its structure, to fit it for effecting the changes which vegetable aliment requires to undergo before it can be converted into blood. It may indeed be



said to consist of four distinct stomachs conjoined. In the first and largest of these, termed the *paunch*, A A, the herbage is deposited when first swallowed after hasty and imperfect mastication. It there undergoes a kind of maceration or steeping in a fluid provided for the purpose; after which it

passes from the paunch into a smaller bag, called the *reticulum*, or bonnet, B, which, in some animals, such as the camel and dromedary, is designed exclusively as a reservoir for water, which being there stored up in large quantities, ready for use when wanted, fits them in a wonderful manner for travelling through the arid deserts where no water is to be obtained, and where, without some such provision, they would of course soon perish. So admirably is the reticulum adapted for this special purpose, that the water contained in it undergoes little or no change either in quality or quantity, although, if it were collected in the ordinary digesting stomach, it would be entirely absorbed in the course of a few minutes. It is not even mixed with the food which is swallowed after it, as the animal has the power of directing solids at once into the other cavities. From the reticulum the alimentary mass is returned to the mouth, there to be thoroughly masticated and mixed with the saliva; after which it descends a second time through the gullet: but instead of passing, as before, into the paunch, it enters the third bag, *omasum*, or many-plies, C, where it undergoes farther changes, and is then transmitted to the fourth portion, D, adjoining the pylorus, and named *ob-omasum*, or red-bag. The last portion is exactly similar in structure and in function to the simple stomach of man and the other mammalia, and is in fact the true stomach, the three others being merely preparatory organs.

The first part of the process, by which the food is taken hastily into the paunch and afterwards sent back to the mouth in detached portions for farther mastication, is called *rumination* or *chewing the cud*, and those species which perform it are thence called *ruminating* animals. Sheep and cows may be seen lying ruminating in pasture-fields after having cropped as much herbage as fills the paunch; and feeding is thus rendered to them a source of prolonged enjoyment.

In those birds, again, which live on hard grain and seeds, and possess no organs of mastication wherewith to bruise or grind them down, another modification of the digestive apparatus is found. Nature has furnished them with a membranous bag, called a *crop* or *craw*, into which the food is received, and where it is slightly softened by a mucous fluid secreted from the surface of the bag. Thus prepared, it is transmitted into an organ analogous to the stomach of other animals, and called the *gizzard*, which has a very singular structure. Its walls are composed of four distinct portions of thick, tough, muscular substance, a large one at each side of the cavity, and a small one at each end. The inner surface of the muscle is lined with an extremely callous cuticle, approaching in hardness to cartilage or horn. When the moistened grain is introduced into the gizzard from the crop, the muscular walls of the gizzard enter into powerful action, and by their alternate contraction and relaxation, bruise the grains as between two grindstones. In some birds, their action is assisted by a quantity of small gravel purposely swallowed along with the food; and it is well known to seamen that poultry never thrive on a voyage, however well they may be fed, if gravel or coarse sand, as well as food, be not placed within their reach. Mr Hunter has counted as many as a thousand small stones in the gizzard of a common goose.*

The astonishing force with which the muscles of the gizzard act, and the resistance of its lining membrane, may be conceived from the experiments of Spallanzani and Reaumur, who compelled geese and other birds to swallow needles, lancets, and other sharp metallic bodies, and, on afterwards killing them, regularly found the points broken off and the edges blunted, without any injury having been sustained by the gizzard itself.

In structure, the stomach of both man and other animals consists of three membranous layers or coats; of follicles or glands; and of numerous blood-vessels and nerves.

The *first* or *external* layer is the

* The above descriptions and figure of the stomachs of the lower animals are taken, with slight alterations, from the Treatise on Animal Physiology in the Library of Useful Knowledge.

smooth, glistening, whitish membrane, which is familiar to all who have ever seen an animal opened. It is a fold of the tough shining membrane called the *peritoneum* (from περιτεινω, *periteino*, I extend round), which lines the abdomen, and constitutes the outer covering of all the abdominal organs. Its use is obviously to strengthen the substance of the stomach, to assist in binding down it and the other organs in their respective situations, and, by the smoothness and constant moisture of their surfaces, to enable them to move upon each other, and adapt themselves freely to their different states of emptiness and distention.

The *second*, *middle*, or *muscular* coat consists of fleshy fibres, one layer of which, running longitudinally from one end of the stomach to the other, seems to be a continuation of the longitudinal muscular fibres of the gullet; while another runs in a circular direction, embracing the stomach from one curvature to the other, and constituting what are called the transverse fibres. The uses of the *muscular* coat have, as we shall afterwards see, a direct reference to the special function of digestion. By the joint action of its longitudinal and circular fibres, the stomach is enabled to contract, and shorten its diameter in every direction, so as to adapt its capacity to the volume of its contents; while, by their successive action, or alternate contraction and relaxation, a kind of churning motion is produced, which contributes greatly to digestion by the motion which it imparts to the food, and the consequent exposure which it effects of every portion of it in its turn to the contact of the gastric juice.

The force and rapidity of these muscular contractions are modified by the more or less stimulant nature of the food, the state of health, exercise, and other circumstances; but, according to Dr Beaumont, the ordinary direction in which they take place, and the course which they impart to the food, are as follows.

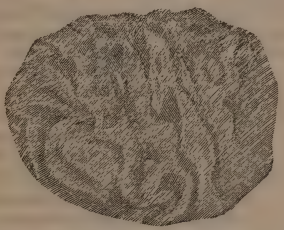
The alimentary *bolus* or morsel, on entering the cardiac orifice, turns to the left, follows the line of the great curvature of the stomach towards the pylorus, returns in the line of the smaller curvature, makes its appearance again at the cardia, and then descends as before to the great curvature, to undergo similar revolutions till digestion be completed. Each revolution occupies about from one to three minutes, and its rapidity increases as chymification advances.

In treating of muscular action in my Principles of Physiology, I pointed out (Chap. VI.) the necessity of the co-operation of a nervous stimulus to produce the result; and remarked that there are two kinds of muscles, one called the *voluntary*, which contract *at the command of the will*, and the other the *involuntary*, over which the will has no control, and which act only in obedience to their own peculiar stimuli. Of the latter description are the muscular fibres of the stomach. They contract when the stimulus of food is applied to them, but we can neither contract nor relax them by an effort of the will, nor are we even conscious of their existence.

It is, indeed, fortunate for us that the necessary motions of the stomach are not entrusted to our guidance, like those of the hand or foot. Supposing that we were to eat three meals a-day, the digestion of each requiring three or four hours,—and that its management depended entirely upon our superintendence,—our whole attention would be required to the process, to the exclusion of every other duty, for ten or twelve hours a-day; and every time that our thoughts wandered for a few minutes, digestion would stand still, and the stomach be disordered by the chemical decomposition of the food which would ensue, so that it would be impossible for us to dedicate any time either to business or to social enjoyment. But from all these inconveniences we are entirely freed by the stomach being placed under the dominion of the involuntary nerves, and so constituted as to perform its functions without any aid from our will.

The *third* and innermost coat, called the *mucous* or *villous*, is that smooth, unequal, velvety membrane, of a red-

dish-white or pale pink colour, which lines the internal surface of the stomach. From being of much greater extent than the two other coats, its surface is thrown into *rugæ*, *plicæ*, *folds*, or *wrinkles*, which are simple in man, but very marked in some animals, as seen familiarly in *tripe*. The annexed woodcut, from the Library of Useful Knowledge, will give some notion of their appearance. Near the pyloric orifice the villous coat is doubled on itself, so as to form a ring, called the *valve* of the pylorus, the object of which is to prevent the too early exit of the food; this object, however, it accomplishes, not by any contractile power of its own, but by the aid of a layer of muscular fibres lying behind it. The villous coat is constantly covered with a very thin, transparent, viscid mucus, and its folds are always best seen in those who die suddenly. After dis-



ease, when the stomach is relaxed, they frequently disappear.

In addition to the folds just described, the mucous coat contains a great number of spheroidal glandular bodies or *follicles*, which lie immediately beneath and almost incorporated with it, and which are most numerous near the pylorus. These follicles differ in function as well as in size; the larger being for the secretion of mucus to lubricate the internal coat, while to the smaller is assigned the important function of secreting the gastric fluid. Some physiologists, and, among others, Dr Beaumont, have imagined that the gastric juice is secreted directly from the capillary (or hair-sized) bloodvessels of the stomach; but the fact that the gastric juice is acid, while the blood is alkaline, certainly militates against this opinion. It is much more probable that the gastric juice is a glandular secretion, derived from innumerable minute follicles imbedded in the mucous coat of the stomach, and which, there is reason to believe, are not confined to that viscus, but extend, though in greatly-diminished numbers, through the greater part of the small intestines.

Of the *bloodvessels* supplying the stomach it is unnecessary to say much. To the general reader, a knowledge of their origin and distribution is not of much importance; because the nature of the red blood is the same by whatever artery it is supplied, and that of the dark blood is the same by whatever vein it is returned to the heart. All that it concerns him to know is, that the stomach receives a large supply of blood by means of numerous bloodvessels, the principal of which, as represented in the cut, fig. 1, page 24, follow the course of the greater and the smaller curvatures, and, as they proceed, send off innumerable small branches to every part of the stomach. When it is empty, and consequently inactive, it becomes contracted into comparatively small bulk, and its bloodvessels become shortened and tortuous in a corresponding degree. The result is both a diminution of their calibre, and a slower circulation through their branches. But when the stomach is full and active, the tortuosity of the bloodvessels disappears, their diameter enlarges, and the circulation through them becomes quicker, and fit for the rapid secretion of the mucous and gastric fluids, in the quantities requisite for the due performance of digestion. Accordingly, when the digestive process is going on, the small arterial branches ramified on the mucous coat of the stomach become so elongated and distended, as to impart to it a deeper red colour than it has when the stomach is empty. The increased afflux of red or arterial blood to the stomach during digestion, is not merely inferred from the analogy of other organs. Many opportunities have occurred of ascertaining the fact; and, as I shall have occasion to mention,

Dr Beaumont very often *saw* it take place.

A corresponding change occurs in the *veins* of the stomach during digestion. Their diameter becomes enlarged, their course more straight, and the current of blood through them more rapid. Their minute or capillary extremities exercise the important function of absorption; it being through their means, with the aid probably of the lymphatics, that liquids are removed from the stomach and thrown into the general circulation.

It may be well to take the present opportunity of calling the reader's attention to the processes of *endosmosis* and *exosmosis*, which, though purely physical phenomena, are calculated to throw much light on absorption and secretion in the living body. When two liquids, or gases, are brought into contact, they have a tendency to diffuse themselves equally through each other, until both acquire a like composition; and this tendency is exerted, to a greater or less extent, even when the liquids are separated by a dense and firm membrane. When a porous partition, whether of membrane, or of any inorganic substance, such as baked clay, intervenes between two liquids, the substance of the partition becomes impregnated with one or other, or with both liquids, and thus the liquids come into contact upon one or other of the surfaces, or in the substance of the partition. If the pores of the partition be such as to admit both liquids with equal facility, they will meet exactly in its middle; but if the pores admit the one liquid with greater facility than the other, then the point of contact and diffusion will be nearest that liquid which has the greatest difficulty in penetrating the pores. When one of the liquids, therefore, passes more readily through the pores of the partition than the other, it diminishes in quantity while the other increases, because it has less obstruction to overcome; and the process continues till the two liquids attain a like composition, and the capillary attraction of the membrane be equalised. Thus, if pure water and a solution of sugar are separated by a piece of moistened bladder, the water passes more readily through the membrane than the saccharine solution does, and consequently the latter increases in bulk. The solution of sugar, however, passes at the same time into the water, and diffusion continues till both liquids attain the same density. But it may happen that the bladder exercises no capillary attraction over one of the liquids—as is the case with alcohol. Accordingly, when water and alcohol are the liquids, the point of contact is on the alcoholic surface of the membrane, and consequently, while the water passes readily into the spirit, the spirit is precluded from passing into the water. A partition of caoutchouc, however, produces an entirely opposite result, clearly proving that the diffusion is dependent alike on the liquid and the partition; the rule being, that that liquid which has the greatest power of penetrating the pores of any interposed substance, passes most readily and in greatest quantity through it. The result is likewise influenced by the state of the surface of the partition. Thus, if one side of the membrane be coated with mucus, and the other be free, the mucus will interfere with the passage of the fluid in contact with it. This process has received the name of *endosmosis*, signifying a flowing in, and *exosmosis*, a flowing out, according as the liquid passes from without inwards, or the reverse. The principle may be extensively applied in the explanation of many physiological phenomena, especially of the process of absorption in the intestinal canal. Thus, when water is introduced into the stomach, it is taken up by the blood on the purely physical principle of endosmosis. The two fluids are separated from each other by the coats of the capillary bloodvessels, through which diffusion immediately commences; but water, penetrating, much more readily than blood, the pores of the capillary coats, flows inwards and disappears, while exosmosis is prevented, as the constant renewal of the blood in the vessel prevents its being placed in equilibrium with the external fluid, till the whole

blood of the body has been saturated. The diffusive current is thus made to flow in a constant stream inwards—in other words, absorption takes place. The rapidity with which this process sometimes goes on is almost incredible, for a large draught of water may be thus absorbed in a few minutes. Fluids mixed with camphor or other strong-scented substances have been given to animals as an experiment, and the peculiar smell has been detected almost immediately in the blood or urine. Most liquids, indeed, and the more soluble portions of the food, are thus absorbed rather than digested.

With regard to the *nerves* of the stomach, much difference of opinion still prevails as to the peculiar influence which each exercises on its functions. We may, however, gather some useful notions by adverting to the different sources whence they are derived, and comparing these with the purposes for which we know from analogy that different kinds of nerves are required.

Strictly speaking, the nervous filaments supplied to the stomach proceed from three distinct sources, and may be held to fulfil as many distinct uses. In apparent accordance with this, we observe three, if not four, distinct classes of operations going on in that organ, each of which may, from analogy, be presumed to require a distinct nerve for its performance. These are, first, the pleasurable consciousness attendant on the presence of wholesome food in a healthy stomach, and which becomes painful and disagreeable when the stomach is diseased or the food of improper quality; secondly, the peristaltic or muscular motion which commences the moment food is swallowed, and continues till digestion is completed; and, thirdly, the different processes of circulation, nutrition, secretion, and absorption, which go on in the several tissues of the stomach and support its life. To these ought perhaps to be added, the sensation in which the feeling of appetite originates; but as it is still uncertain whether it and the first of the three now named are not modifications of the same thing, I shall not insist on considering them as different.

It is not easy, in so complicated a process, to determine the mode in which the nervous agency affects the functions of the stomach; but nobody ventures to deny the reality of the influence which it exercises. The existence of that influence is manifest in the disturbing action of strong mental emotions; in the loathing and sickness so often consequent on the sudden reception of disagreeable news; in the cessation of digestion as a consequence of the section of the stomachic nerves, and in its re-establishment when a galvanic current is directed upon the cut end of the nerve in connexion with the stomach. In all these cases, the effect is certainly produced exclusively through the medium of the nerves, although the manner of its production may be explained in various ways. It may arise, for example, partly from the secretion of the gastric juice being prematurely arrested; partly from the cessation of the muscular action in the stomach, putting a stop to that gentle agitation of its contents which is necessary for their adequate mixture with the gastric juice; and partly in some other way altogether unknown to us. But as the fact itself is not disputed, and as that influence, whatever it may be and however it may act, is not generated in the nerves themselves, but is dependent on their connexion with the brain and spinal marrow, I may be allowed to speak, in a popular way, of "the influence of the nervous energy upon digestion," not as implying any particular theory, but as embodying an important practical truth, which ought never to be lost sight of in the regulation of our conduct.

The importance of the nervous agency in digestion has been denied, because we are not *conscious* of the presence of food in the stomach. But in health the want of such consciousness is a privilege and not a defect; and it has been admirably pointed out by Dr Southwood Smith,* that in possessing, as we do, the distinct consciousness of a *pleasurable* feeling in the stomach after indulging in a suitable meal, we have all that is desirable for either utility or

* Philosophy of Health, vol., i., p. 80.

enjoyment. If we were aware of the presence of every portion of food which the stomach contains, and of the changes occurring in each, our attention would be so disagreeably and unprofitably taken up, that we should pray to be delivered from the annoyance. Where, however, from disease, or the food being inappropriate, the stomach is injured by what is eaten, consciousness becomes painful, for the express purpose of warning us that mischief has been done, and that we must take means for its removal. In some kinds of dyspepsia, indeed, the sensibility becomes exalted to an extraordinary degree. Barras, who suffered intensely from this cause, says of himself, "The sensibility of the stomach increased to a surprising extent; instead of organic it became animal, to use the expression of Bichat. Every thing which took place in the principal organ of digestion became as palpable to sense as if it had taken place on the organ of touch, and the presence of aliment was perceived as clearly as if it had been under my hand."*

The nerves of the stomach, it ought to be remarked, have a direct relation to *undigested* but *digestible* substances; in other words, undigested food forms their natural and appropriate stimulus; and hence the acute observation made by Blondlot, that galvanism is effectual in exciting the gastric secretion, and the muscular contractions of the stomach, only when there is food within it on which to act. In consequence of this arrangement, when any body incapable of digestion is introduced into its cavity, distinct uneasiness is speedily excited, and an involuntary effort is soon made to expel it either upwards by the mouth or downwards by the bowels. It is in this way that bile in the stomach excites nausea, and often produces vomiting. In like manner, the nerves of the bowels bear a direct relation to the presence of food already digested in the stomach, or capable of digestion in the bowels; and consequently, when anything which resists alike gastric and intestinal digestion escapes from the stomach, it becomes to the nerves of the bowels a source of irritation. Hence the colicky pains and bowel-complaints which so commonly attend the passage through the intestinal canal of such indigestible substances as fat, husks of fruits, berries, and cherry-stones.

* Cyclop. of Pract. Med., vol. ii., p. 635.

Such, then, is a general description of the stomach, or organ in which the food is converted into chyme. To preserve the thread of connexion unbroken, I shall now briefly direct the attention of the reader to the organs concerned in the subsequent stages of digestion and assimilation, and then return to the consideration of these processes themselves, and of the practical conclusions which may be derived from their history.

CHAPTER VI.

ORGANS CONCERNED IN INTESTINAL DIGESTION.

Chylification—Organs concerned in it—The duodenum, and general description of the intestines—their coats and absorbent vessels—The chyle and thoracic duct—The liver, its position and uses—The bile and gall-bladder—The pancreas or sweet-bread, and pancreatic juice—The bile and pancreatic juice aid in the formation of chyle from chyme.

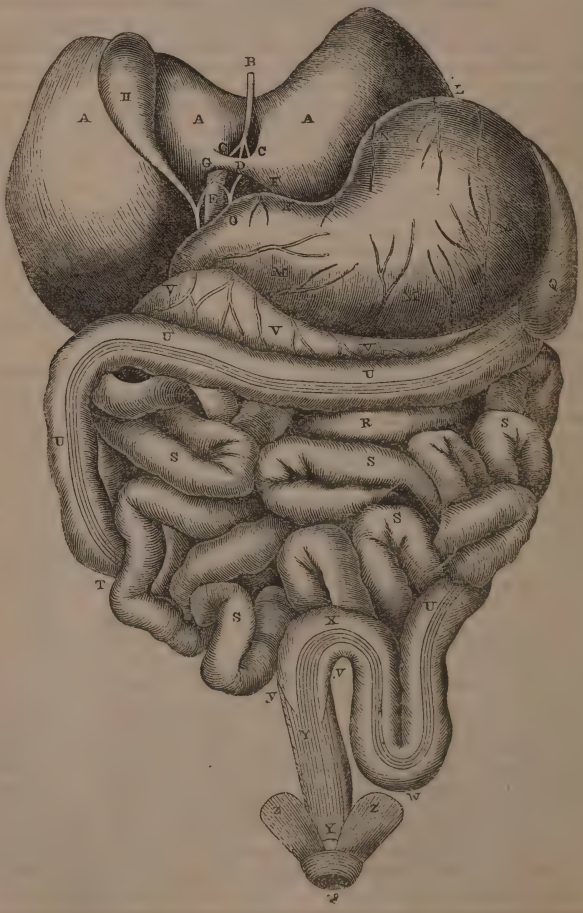
HAVING undergone the necessary changes in the stomach, the alimentary mass is next propelled, in the form of chyme, into the duodenum or small intestine, there to undergo certain other changes, the first of which is its conversion into chyle under the joint action of the bile and pancreatic juice. To this part of the process the name of *intestinal digestion* is often given, and with perfect propriety, both because the changes alluded to actually take place in the intestine, and because without their occurrence, chyme cannot be converted into proper nutriment for the animal frame.

The organs more immediately concerned in *chylification*, or the conversion of chyme into chyle, are the *duodenum*, the *liver*, and the *pancreas*; and

on each of these I shall make a few remarks.

The *duodenum* is that portion of the bowels which is continuous with the stomach, and extends, in man, to about twelve inches in length, when the bowel takes the name of the *jejunum*, but without any very marked difference in structure. These, along with the *ileum*, which is the continuation of the jejunum, constitute what are called the *smaller intestines* (as represented at R S S S S S in the next figure), to distinguish them from the *colon* and *rectum*, or *larger intestines*, seen at U U U U W X Y Y. The smaller intestines constitute by much the greater part of the whole, and differ somewhat from the larger in both structure and function. Their general nature is, however, so

THE LIVER, INTESTINES, &c.



closely analogous, that all may, at present, be included in the same description.

Like the stomach, the intestines consist of three coats or layers of membrane; the *outer* or *peritoneal*,—the *middle* or *muscular*,—and the *internal*, *mucous*, or *villous*.

The *peritoneal* coat is the white, firm, smooth, shining, and moist membrane, seen on the outside of the intestine on opening the cavity of the abdomen. It serves as a support and a medium of attachment to fix the intestine in its place. By means of its smooth, soft, and lubricated surface, it admits readily of the change of place among the bowels necessarily produced by respiration, exercise, and even by different degrees of distention of the bowels themselves. Every time we breathe, an undulating motion is communicated to the whole intestines, which facilitates their action, but which could not take place unless they were capable of gliding easily and freely over each other. The peritoneal coat, being strong, extensible, and elastic, is very useful also as a support to the other coats.

The *muscular* coat is composed principally of transverse and longitudinal fibres; and its sole object here, as in the stomach, is to effect motion. By the alternate contraction of the two kinds of fibres, the *peristaltic motion* (from *περιστελλω*, *peristello*, I contract,) is produced; by which the contents of the bowel are gradually propelled in a downward direction, just as we see a motion propagated from one end of a worm to the other; and hence it is sometimes called the *vermicular* or *worm-like* motion (from *vermis*, a worm). Some nauseating substances, such as emetics, have the power of *inverting* the order of the muscular contractions, and directing the contents *upwards* instead of *downwards*—whence vomiting ultimately arises. Other substances, again, have the property of exciting the *natural* action to a higher degree, and consequently propelling the contents rapidly downwards—in other words, of purging. Rhubarb, aloes, and similar laxatives, especially when combined with tonics, act in this way, and are, consequently, best adapted for obviating the kind of costiveness which arises from imperfect intestinal contraction. In a natural mode of life, the muscular coat is greatly aided in its operation by the large abdominal and thoracic muscles, brought powerfully and frequently into play during active exercise and employment. When this aid is withdrawn, as it is in sedentary people, the intestinal action often proves insufficient for the purpose; and hence the costiveness which is so general an attendant on those females, literary

VILLOUS COAT OF INTESTINE.

C

men, and others, whose occupations deprive them of active muscular exercise in the open air. In females, the use of tight stays renders the free expansion of the chest and corresponding motion of the abdomen altogether impossible, and thus aggravates the evils of their sedentary mode of life. Hence also the peculiar fitness, in such cases, of the class of purgatives above alluded to, in preference to those of a saline nature, which act chiefly by stimulating the mucous surface to farther secretion.

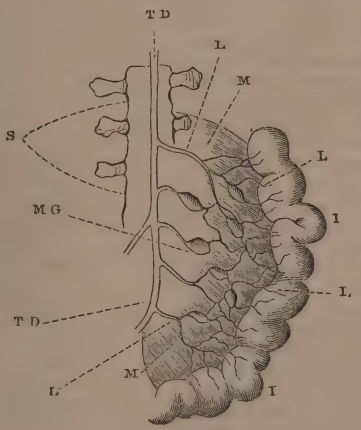
The *mucous*, *internal*, or *villous* coat of the intestine, also resembles, in many respects, that of the stomach. It is a soft velvety membrane, full of transverse wrinkles or folds, called the *valvulæ conniventes*, by means of which the extent of its surface is greatly increased, so as to afford ample space for the ramification of the bloodvessels, nerves, and absorbents, with which it is very plentifully supplied. These folds are large and thickly placed in the duodenum and jejunum, where absorption proceeds with greatest activity. They begin to diminish both in size and closeness of juxtaposition as they approach the ileum, towards the middle of which they altogether disappear. The surface of the mucous membrane of the small intestines is thickly studded with minute vascular projections, called *villi*, which vary in length from a quarter of a line to a line and two-thirds, and to which the peculiar velvety appearance is owing. The woodcut on page 33 will convey some idea of the appearance of the mucous membrane, as seen in the smaller intestines. So far as nutrition is concerned it is the truly *essential* part of the bowel. It alone is in direct contact with the chyme, and in its cavity the bile and pancreatic juice perform their respective parts and give rise to the formation of chyle, which is afterwards transmitted from its surface into the general system. The peritoneal and muscular coats are useful only in affording protection and communicating the power of propelling its contents.

The mucous coat appears, on examination, to be entirely continuous with the skin. In structure the two greatly resemble each other, and an intimate sympathy exists between them. Eruptions on the skin, for example, are frequently owing to disorder of the digestive organs; and bowel-complaint, on the other hand, is often produced by a sudden chill on the surface. In like manner, in enormous eaters, like those I shall afterwards mention, an immense exhalation takes place from both the skin and the bowels, and, in many instances, the one supplies the place of the other in a considerable degree. In the lowest tribes of animals, moreover, the digesting surfaces and skin are not only undistinguishable, but actually convertible into each other by the simple process of turning the animal inside out—a clear proof of similarity of both structure and function.

In common with the skin, too, the mucous coat is charged with the double function of *excretion* and *absorption*. For the former, it is eminently fitted by its plentiful supply of blood, by the great number of minute vessels ramified on its surface, and by the immense number of its follicles. It is by this channel that much of the waste matter requiring to be removed from the body is thrown out. Being poured into the cavity of the intestine it mixes there with the indigestible residuum of the food and bile, and, united with them, forms the fæces or excrement. When the blood is suddenly repelled from the surface of the body by a chill, and thrown in upon the mucous membrane in large quantity, the natural excretion is sometimes increased to such an extent as to constitute bowel-complaint; while, at other times, that peculiar form of action is induced which constitutes inflammation. The local stimulus of some kinds of food, and of many medical substances, also excites the secretion to unusual activity. Salts, for instance, have this effect, and thus often *produce* numerous fluid evacuations, the substance or materials of which did not before exist in the bowels; and hence the mistake into which many fall, of taking more medicine, on the ground of this effect proving that much stuff was lodged in the bowels—when,

in fact, it was not only removed, but previously *brought* by the physic. It is from exciting a fluid discharge of this description, that saline purgatives are so useful for lowering the tone of the system when that is required; but for the same reason, they are most improper where relaxation and debility already exist. An explanation has been attempted of the action of salts, on the principle of exosmosis. The saline solution, it has been suggested, attracts a large quantity of liquid from the blood; this action continues till an equilibrium be established between the saline contents of the two fluids; and if, to complete the equilibrium, a large quantity of liquid be taken from the blood, its presence irritates the bowels, and watery evacuations are produced. This theory, however, will not stand investigation; for the action which different salts produce is far from being proportionate to the quantity swallowed, a small dose of one producing much more violent effects than a large quantity of another. It is much more probable that they act either directly, by stimulating the mucous glands to more copious secretion, or indirectly, by being absorbed and acting on the nervous system. In Asiatic cholera, almost the whole fluids of the body, evidently in consequence of a morbid change in their composition, are carried off by the bowels, leaving the blood too thick in consistence to circulate longer through the smaller vessels.

The excretions from the minute follicles are mingled with a bland fluid from the larger glands similar to those of the stomach, the evident use of which is to protect from injury the sensitive surface of the intestine. Occasionally, however, this mucous secretion becomes so abundant and viscid, as to adhere with unusual force, and to impede the formation and absorption of the chyle, and even the action of the usual purgatives.



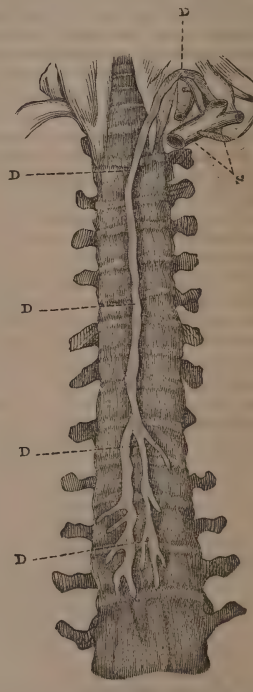
Worms are then common, and cannot be expelled except by remedies that tend to remove the mucus in which they live imbedded.

To fit the mucous coat for its office of *absorption*, an immense number of minute vessels, called *absorbents*, are ramified on its internal surface. The nature and purposes of these are analogous to those of the absorbents of the skin, described in my former work.* In both structures the absorbents are small capillary vessels, so extremely

* Principles of Physiology, &c., chap. ii.

numerous that at least one goes to every little point, *papilla*, or *villus*. Those which originate upon the inner surface of the smaller intestines, and which suck in or absorb the chyle, are called *lacteal absorbents*, or simply the *lacteals* or milk-vessels (marked L L L L in the preceding woodcut), from the white colour of the chyle shining through them, and giving them the appearance of vessels full of milk. In that part of the gut they proceed from the villi, each of which receives one or two small arteries along with one or more lacteals. During the period of digestion the villi are increased in size, owing to the distention of their absorbents by the chyle; and as they are very thickly studded together, being in the proportion of about twenty-five to the square line, the mucous membrane then acquires a whitish look. The use of the villi is probably to increase the extent of the absorbing surface: at all events it is evident that their presence is not indispensable to absorption, as experience shews that nutritive principles are readily absorbed by the stomach and large intestines, neither of which possess villi. Even in the colon the absorbents are numerous; but, as all traces of chyle have there disappeared, they are fewer and less easily recognised than in the smaller intestines. In the colon they serve chiefly to remove the more watery portions of the intestinal contents, thus rendering the fæces more solid and less bulky, and therefore better adapted for being retained for a time without inconvenience. It sometimes happens, that when food or medicine cannot be swallowed in the usual way, life is preserved by injecting it into the bowels; in which case the absorbents of the large gut become active, and carry it into the system. Strong soups, milk, opium, laxatives, and other remedies, are often administered in the same way, when any reason exists against giving them by the mouth.

The lacteal vessels are most easily seen an hour or two after a meal; because they are then fully distended with chyle, even in their smaller branches. The latter, indeed, may then be distinctly traced proceeding from the different portions of the intestine, and gradually coalescing into larger trunks, as seen at L L in the foregoing figure. These, again, terminate in the vessel called the thoracic duct (the beginning of which is seen at T D in the same figure), by which the chyle is conveyed almost in a direct course along the spine, and which is represented at D D D D in the subjoined cut. On its arrival at the upper part of the chest, the thoracic duct



crosses over and opens into the subclavian vein S, just before the latter reaches the right side of the heart, so that the chyle is there poured into the circulating current of the *venous* blood.

Such is the course of the chyle. But

the lacteal absorbents, in their progress from the intestine to the thoracic duct, pass through the small glandular bodies called the mesenteric glands (MG, p. 35), where some change, the nature of which is not well understood, is produced upon the chyle, and which seems to be of importance to its constitution. Where these glands are hardened and enlarged, as they often are in scrofulous children with large prominent bellies and thin bodies, nutrition is greatly impaired, although the appetite and stomachic digestion may remain comparatively unaffected.

We have seen above that the capillary bloodvessels are actively employed in absorption, so that there exist two channels for the introduction of nutriment into the blood—the veins and the lacteals. It is probable that the veins are called into action when the fluid is capable of being directly assimilated with the blood, while the lacteals absorb those fluids which require in the first place to be submitted to the peculiar action of the mesenteric glands, whatever that may be. In corroboration of this theory, it is found, that the contents of the lacteals approach more and more to the constitution of blood, the farther they have advanced on their way to the subclavian vein. It is worthy of notice, also, that, at their origin, the lacteals are surrounded by a plexus of capillary bloodvessels, which probably act upon the chyle before it reaches the lacteal, and prepare it for absorption

by the latter. The prefixed woodcut* represents an ideal section of a villus:

* Copied from Valentin's Lehrbuch, vol. i., p. 382.

a b is the epithelium, or epidermic coat of the mucous membrane, which is supposed by Goodsir to be thrown off at each period of digestion, in order to allow absorption more readily to take place, in consequence of the chyme being brought into contact with the naked villus. The lacteal is seen at *d* surrounded by the capillary bloodvessels *c*; and the space intervening between them and the epithelium is occupied by mucous membrane and cellular tissue. The veins and lacteals appear therefore to have each their appropriate functions, and to exercise, to a certain extent, the power of selection. Thus, the lacteals reject with obstinacy all colouring matter, but readily take up fat; while, on the other hand, fat is rejected by the veins, which, again, readily absorb colouring matter. It is not, however, asserted that the veins and lacteals may not both absorb the same substance; in all probability they do so, and the prevailing action of the one or of the other may depend to a certain extent upon the degree of consistency possessed by the chyme.

Chyle, although much altered in its passage through the mesenteric glands and along the thoracic duct, is still not fitted to become a constituent part of the animal frame. *It must first be converted into blood*; and this can be effected only by exposing it to the action of the air in the air-cells of the lungs, in a state of intimate mixture with the venous blood. This admixture, again, is insured by the gradual way in which the chyle advances along the thoracic duct and falls into the circulating current almost drop by drop; and it takes place just when the dark blood is about to finish its course, and to be again subjected to complete *aëration* in its passage through the lungs. As explained in my former work, this aëration is so indispensable to the renovation of the old and the formation of new blood, that whenever it is rendered imperfect, either by obstructions in the lungs themselves or by the absence of a sufficiently pure air without, the result is invariably injurious to health; because the blood, being no

longer properly constituted, becomes incapable of furnishing a healthy stimulus and nourishment to the body. Hence the rapid "decline" which follows the appearance of pulmonary consumption, and of other diseases affecting the structure and interrupting the functions of the lungs.

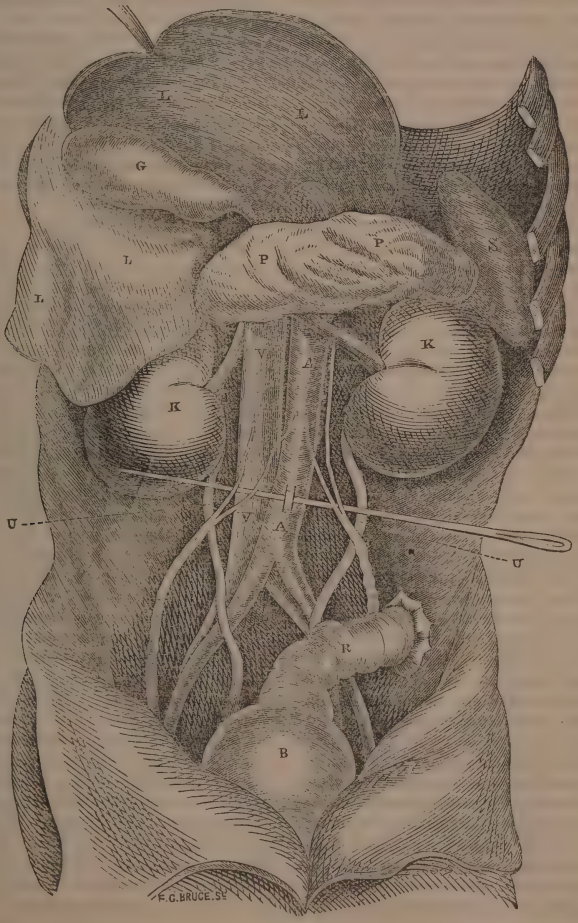
Every body knows as a fact that bad air is hurtful, and that wasting disease of the lungs is attended with rapid loss of flesh and strength; but the manner in which these effects are produced is not so familiarly known. Yet, in a practical point of view, a knowledge of the principle is highly important. Properly considered, *respiration is, in truth, the completion of digestion.* The stomach may convert the food into chyme, the small intestines may convert the chyme into chyle, and the absorbents may take up the latter and duly convey it into the circulating system; but unless it undergo the necessary change in the air-cells of the lungs, it will not constitute good blood or afford due nourishment to the body. Hence it is that those among the working-classes who are much confined in an impure and insalubrious atmosphere, are, even when plentifully supplied with food, generally thin and ill-nourished; and hence, those who, along with good digestion, have small narrow chests and very limited respiration, are commonly found to be constitutionally lean—while those who, along with good digestion, have amply-developed lungs and free and powerful respiration, are at the same time remarkable for proportional vigour of nutrition and stoutness of body. It is on this account that in chronic pulmonary disease apparent recovery is always to be distrusted, unless, along with the disappearance of the prominent symptoms, restoration of the lost flesh occurs. If nutrition remains impaired, however great the relief may be in other respects, there is reason to believe that disease of the lungs is still so extensive as to injure their functions, and that, on the application of any fresh exciting cause, the dormant mischief will resume its activity. In such cases, when stomachic digestion is sound, a full diet generally overstimulates the system, by pouring into the blood more chyle than the lungs are able to assimilate; in consequence of which it is diffused over the body in an imperfect state of preparation.

The nutritive part of the food being thus removed from the intestines in the form of chyle, the remaining innutritious portion, and the waste materials from the rest of the system, are gradually propelled downwards till they arrive at the external orifice, through which they are ultimately expelled from the body. This propulsion of the intestinal contents is effected chiefly by the *peristaltic* or *vermicular* motion (that is, the successive muscular contractions of the middle or fleshy coat, already frequently mentioned); and this, in its turn, is greatly aided by the constant but gentle agitation which the whole digestive apparatus receives during the act of breathing, and during exercise of every description. In inhaling air into the lungs, the diaphragm is depressed, the bowels are pushed down, the walls of the belly yield, and it becomes protuberant. When air is thrown out from the lungs, the diaphragm rises into the chest, the bowels follow, and the belly becomes flattened and drawn in. The stomach and bowels are thus placed between, and receive a never-ending impulse from two bodies in continual motion. During exercise, breathing is deeper, and muscular contraction greater in power and in extent, than during repose; and, hence, the assistance afforded is also increased. Those who take no exercise, or who have the chest and bowels confined and bound down by tight stays and bandages, lose this natural stimulus, and have, in consequence, the bowels obstinately and troublesomely costive.

The next organ concerned in intestinal digestion is the *Liver*, with the name of which every one is familiar. The liver—L L L L in the woodcut on next page—is a large glandular body lying under the short ribs of the right side, immediately below the diaphragm or midriff, to which it is attached by strong ligamentary bands, which sus-

tain its weight and keep it in its place. Its office is to secrete the bile, but it differs in one important particular from every other secreting organ. Its secretion is derived, not, as in other instances, from the arterial or nutritive blood, but from the *venous* blood, which is collected from all the abdominal organs, and transmitted through it for this purpose on its way back to the heart. This peculiarity ought to be kept in mind, because, as we shall afterwards have occasion to notice, it bears directly upon the functions of the liver, and the relation in which this organ stands to the rest of the animal economy.

The secretion of bile goes on continually, though it is always most active after a meal, the supply of blood in both the arteries and veins of the liver and



neighbouring organs being then at its maximum. As, however, most animals eat only at intervals, and the presence of bile is required only when the duodenum contains chyme, some contrivance becomes necessary for storing it up to be ready for use when wanted. This is effected by the small pear-shaped sac or bag named the *gall-bladder* (seen at G in the woodcut on the preceding page, attached to the lower surface of the liver), and which is, of course, always most full after a fast of some duration. In many animals, however, especially in those which are constantly eating, there is no gall-bladder, and the bile flows into the intestine as fast as it is secreted, because it is then constantly required.

Recently-secreted bile is a bitter, viscid, greenish-yellow fluid, the taste and general appearance of which are familiar to most people, and the office of which in the animal economy must be one of no small moment, if it be justly chargeable with even a tenth part of the catalogue of human ills which are laid to its account. But that contained in the gall-bladder is generally more viscid, dark, and bitter—apparently from the absorption of its more fluid parts, and its consequently greater concentration. It is in this bag that *gall-stones*, as they are called, are sometimes formed; and it is their passage through the narrow tube in which it terminates, that causes the acute pain so often complained of in that affection.

In the healthy state, bile is to be found only in the intestine, and not in the stomach; although one might suppose the contrary from the familiar way in which people speak of the stomach being oppressed with bile, and of their being "very bilious." When vomiting is excited, either artificially or by illness, bile is, no doubt, often brought up in some quantity; but in general this does not arise from bile pre-existing in the stomach. The very act of vomiting is accompanied by an inverted action of the intestinal canal, whereby it propels its contents upwards instead of downwards; and thus the bile is forced up from the duodenum into the stomach, instead of going downwards in the usual way. Hence, in sea-sickness, for example, the first fits of retching generally bring up nothing but food or mucus—the real contents of the stomach,—and it is only after continued straining that bile makes its appearance. In the healthy state, fat or oily food often causes the presence of bile in the stomach, as if its aid were necessary there for the accomplishment of the gastric stage of digestion.

The *Pancreas* or sweetbread—P P in the preceding woodcut—is the next organ concerned in chylification. Its office is to secrete a fluid closely resembling the saliva, and which is effused into the duodenum along with the bile; thus leading to the presumption, that the intermixture of both fluids with the chyme is essential for its due conversion into chyle.

Much difference of opinion exists regarding the share which the bile takes in the formation of chyle. Most physiologists consider it to be indispensable, while Blondlot and others affirm that chyle may be formed and absorbed without the assistance of bile, and that the latter is purely excrementitious. It is certainly true that chyle may be formed without bile; but Schwann's experiments nevertheless prove, that when the bile is conducted out of the system by an artificial opening and not allowed to mix with the chyme, the animal soon begins to droop, and dies in a few days.* Liebig regards the bile as an important means of restoring carbon to the system for the generation of animal heat; and his opinion derives some confirmation from the fact, that certain principles of the bile disappear during its passage along the alimentary canal. We shall afterwards see that the probable use of the pancreatic juice is to promote the digestion of farinaceous and vegetable food; but without at present entering upon a discussion which the general reader could not understand, it will be sufficient simply to repeat, that the chyme on entering the duodenum becomes mixed with the bile and pan-

* Müller's Archiv, 1844, p. 127.

creatic juice, and that the result is its separation into two portions—the one a white, milky, nutritive fluid, named *chyle*, which is absorbed and carried into the current of the blood by the lacteal vessels and veins; and the other a darker, yellow-coloured, thickish mass, which remains in the bowels till, after various changes, it is expelled in the form of excrement. How these changes are brought about, and what is their precise chemical nature, I shall not now stop to inquire, as I shall have occasion to refer to the little that is really known regarding them when I come to treat of the practical applications in a subsequent chapter.

CHAPTER VII.

AGENTS CONCERNED IN DIGESTION—THE GASTRIC JUICE, ITS PROPERTIES AND MODE OF ACTION.

Difficulties in the study of digestion—Sources of fallacy—The gastric juice the chief agent in digestion—Modes of studying its action—Singular case of Alexis St Martin, and facilities afforded by it—Blondlot's experiments—The gastric juice secreted by the glands of the mucous coat—Its appearance and properties—Its secretion depends on the presence of food—Acts only on organized substances—Limitation of quantity secreted, and of its solvent power—Its secretion arrested by disease—Owes its solvent power to the principle called pepsin—Different theories of digestion—It is a chemical solution in the gastric juice—Action of gastric juice out of the body—Illustrative experiments—It acts only in direct contact with food—Their mixture effected by the muscular contractions of the stomach—Heat necessary to the action of the gastric juice—Proofs—Mode of action of gastric juice—Summary of changes caused by it—Its action differs on different substances—Examples of fibrine, milk, albumen, and vegetables—Blondlot's views of its mode of action on different aliments—Specialty of its action—Artificial digestive liquor—Temperature of the stomach during digestion—Dr Beaumont's inferences from his experiments and observations.

HAVING thus completed a cursory survey of the various organs concerned in digestion, and indicated the share which each takes in the production of the general result, we are now prepared to carry our inquiry a little farther, and to investigate with greater interest the nature and laws of action of the agents by which the required changes in the alimentary mass are chiefly brought about. Let us begin with the gastric juice, unquestionably the most important of them all.

At first sight, the impossibility of witnessing, during life, the changes which the food undergoes in the stomach, appears to present an insuperable obstacle to our ever becoming acquainted with the nature of the digestive process, or with the agents by which it is accomplished. Great, however, as the difficulty is, it has been in a great measure surmounted, partly by well-contrived experiments on man and the lower animals, partly by observations made in cases of wounds or disease which laid open the interior of the stomach during life, and partly also by examining the stomach and its contents in persons suddenly cut off at different intervals of time after eating.

The only unsatisfactory feature of the important information thus procured, has been, that even when perfectly correct in all its leading features, *conclusive evidence* of its accuracy has not always been easily attainable. From the close sympathy existing between the stomach and all other parts of the system, and the consequent facility with which the digestive functions are disturbed by affections of other organs and by strong mental emotions, conclusions drawn from experiments on living animals, and from diseased states in man, can never be relied upon with the same entire confidence as those derived from observation of normal phenomena. Of the truth of this remark, we have ample evidence in the facility with which the soundest and best-established opinions regarding digestion have at times been shaken, if not set aside, by the plausible, but really erroneous, results of experiments, the fallacy of which it was at first difficult to detect. As an example in point, I need only refer to the shock given, a few years since, by the plausible but wholly deceptive experiments of Montegre, to the prevailing views regarding the properties of the gastric juice. Montegre possessed the unenviable faculty of vomiting at will; and, taking for granted that whatever was discharged from his stomach after a fast of some hours, must necessarily

be gastric juice, he proceeded to experiment on the fluid thus obtained; and finding its properties to be almost identical with those of saliva, and widely different from those assigned to gastric juice by Spallanzani and other physiologists, he forthwith proclaimed the latter fluid to be in reality a mere mucous secretion, as destitute of active properties as the saliva itself.

When Montegre published these extraordinary conclusions, it had not been *demonstrated*, as it has since been by direct observation, that *the gastric juice is never secreted unless under the stimulus of food actually present in the stomach.* Had this simple fact been known, all his sweeping deductions would have been at once set aside by the now obvious fact, that his experiments had no concern whatever with the true gastric juice, of which his stomach had contained none, but merely with the mucous secretion of the villous coat, which had been long known to resemble the saliva in most of its properties. No wonder, then, that many physiologists, equally in the dark with himself as to the non-existence of gastric juice in the stomach during a fast, were, for a time, startled by the threatened overthrow of the received opinions, and did not regain confidence in the soundness of these, till subsequent experiments had once more confirmed their accuracy, and clearly demonstrated the source of Montegre's error.

The first step, then, towards ascertaining the properties of the gastric juice, and its mode of action on different kinds of food, is to make sure that we obtain it for the purposes of experiment in its utmost possible purity. The necessity for this precaution becomes evident, when we consider that its active properties must be modified by every admixture with mucus; and that, in certain states of disease, the mucous secretion becomes so abundant as greatly to interfere with the progress of digestion, and to mislead those who, like Montegre, assume it and the gastric juice to be one and the same fluid.

In most of the instances in which disease or wounds had laid open the interior of the stomach during life, the accompanying constitutional disturbance was so great as either speedily to destroy life, or to derange, in a high degree, the regularity of all the vital functions. From this circumstance, little advantage could be derived from them, either in procuring pure gastric juice, or in studying the phenomena of healthy digestion. In a very remarkable case, however, which occurred about twenty-five years ago, and which is, perhaps, the only one on record in which a permanent opening into the stomach existed for years without the slightest injury either to the soundness of digestion or to the general health, Dr Beaumont possessed unusual facilities for the avoidance of this and every other source of error. It was fortunate, therefore, that the case should have fallen under the professional care of an observer so well qualified to turn it to account.*

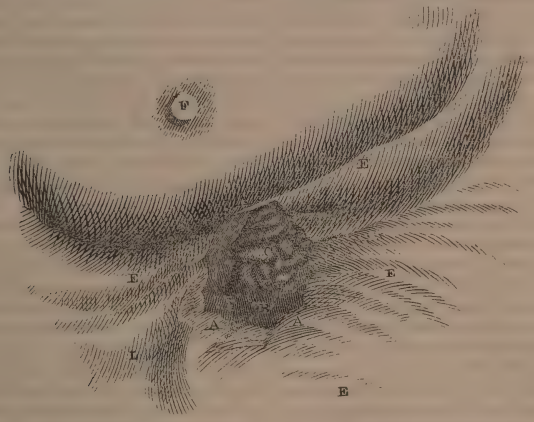
The subject of Dr Beaumont's experiments was Alexis St Martin, a young Canadian of eighteen years of age, good constitution, and robust health, who was accidentally wounded, by the discharge of a musket, on 6th June 1822. The situation and appearance of the wound, and of the opening it left into the stomach after his recovery, will be at once understood from the inspection of the subjoined woodcut.

"The charge," says Dr Beaumont, "consisting of powder and duck-shot, was received in the left side, at the distance of one yard from the muzzle of the gun. The contents entered posteriorly, and in an oblique direction, forward and inward; literally blowing off integuments and muscles to the size of a man's hand, *fracturing and carrying away the anterior half of the sixth rib, fracturing the fifth, lacerating the lower portion of the left lobe of the lungs, the diaphragm, and* PERFORATING THE STOMACH."

On the fifth day, sloughing took place; lacerated portions of the lung and stomach separated, and left a perforation into the latter, "large enough

* Experiments and Observations on the Gastric Juice, and the Physiology of Digestion: by William Beaumont, M.D. Reprinted, with Notes, by Andrew Combe, M.D. 1 vol. post 8vo. Edinburgh, 1838.

to admit the whole length of the middle finger into its cavity; and also a passage into the chest half as large as his fist." Violent fever and farther sloughing ensued; and for seventeen days every thing swallowed passed out through the wound, and the patient was kept alive chiefly by nourishing injections. By-and-by the fever subsided, the wound improved in appearance, and after the fourth week the appetite became good, digestion regular, the evacuations natural, and the health of the system complete. *The orifice, however, never closed;* and at every dressing the contents of the stomach flowed out, and its coats frequently became everted or protruded so far as to equal in size a hen's egg, but they were always easily returned. The annexed figure exhibits the appearance of the wound after it was healed. The circumference of the wound, E E E E L, extended to about twelve inches; and the opening into the stomach, A A A, nearly in its centre



was about two inches below the left nipple F. The folds of the villous coat of the stomach are visible at C B.

Some months after, St Martin suffered extremely from the death and exfoliation of portions of the injured ribs and their cartilages, and his life was often in jeopardy; but through the skill and unremitting care with which he was treated by Dr Beaumont, he ultimately recovered, and, in April 1823, was going about, doing light work and rapidly regaining strength.

On 6th June 1823, a year from the date of the accident, the injured parts were all sound, except the perforation into the stomach, which was then two-and-a-half inches in circumference. For some months thereafter the food could be retained only by constantly wearing a compress and bandage; but early in winter, a small fold or doubling of the villous coat began to appear, which gradually increased till it filled the aperture and acted as *a valve*, so as completely to prevent any efflux from within, but to admit of being easily pushed back by the finger from without.

Dr Beaumont began his first series of experiments in May 1825, and continued them for four or five months, St Martin being then in high health. In the autumn, St Martin returned to Canada, where he married, had a family, worked hard, engaged as a voyageur with the Hudson's Bay Fur Company, and, after four years, was engaged at a great expense by Dr Beaumont to come and reside near him on the Mississippi, for the purpose of enabling him to complete his

investigations. He came accordingly in August 1829, and remained till March 1831. He then went a second time to Canada, but returned to Dr Beaumont in November 1832, when the experiments were once more resumed and continued till March 1833, at which time he finally left Dr Beaumont. He now enjoys perfect health, but the orifice made by the wound remains in the same state as in 1824. A report has lately reached me, but I know not how far it is correct, that Dr Beaumont purposes commencing a fresh set of experiments. Should this intention be realised, the results are likely to be of great importance in settling many doubtful points, on which the late rapid progress of physiology has already thrown considerable light.

Dr Beaumont describes the aperture in St Martin's stomach as being situated about three inches to the left of the cardia, near the left or superior termination of the great curvature. When the stomach was nearly empty, he was able to examine its cavity to the depth of five or six inches by artificial distention. When it was entirely empty, the stomach was always contracted on itself, and the valve generally forced through the orifice, together with a portion of the mucous membrane, equal in bulk to a hen's egg.

Here, then, was an admirable opportunity for experimenting on the process of digestion, and for observing the healthy and undisturbed operations of Nature free from the agony of vivisections, and from the sources of fallacy inseparable from operating on animals, and with almost as much facility and precision as if the opening into St Martin's stomach had been made on purpose. St Martin's health was robust; his diet and mode of life were entirely under Dr Beaumont's control; and the experiments, which were conducted with great caution and soundness of judgment, were continued during a series of years, which admitted of their frequent repetition under every variety of circumstances. Since the publication of Dr Beaumont's work, also, several eminent French and German physiologists, influenced by his example, have repeated his experiments on animals, and borne the strongest testimony to his accuracy in every essential particular. This has been the case in a remarkable degree with Blondlot, whose confirmatory evidence is the more valuable, because the experiments on which it rests were, in imitation of those on St Martin, made through an artificial opening into the stomachs of dogs, after their complete restoration to health, and were, moreover, performed with the greatest care. Influenced by all these reasons for confidence in the accuracy of Dr Beaumont's observations, I shall not hesitate to take him for our chief guide on the present occasion; because even facts which have been long known acquire, in his hands, that character of certainty which direct observation alone can impart, but which is not the less necessary to stamp their scientific value.

For a long time the true *origin of the gastric juice* was a matter of dispute. By many it was supposed to proceed from the mucous follicles near the pylorus. But through the opening in St Martin's side, Dr Beaumont was at last enabled to ascertain, by ocular inspection, that the lining membrane of the stomach is its true source, and that the follicles secrete only the bland, viscid mucus already referred to. Dr Beaumont had little difficulty in assuring himself of this fact, because, as we have seen, a large portion of the inner surface of St Martin's stomach was generally exposed to observation at the opening.* This protruded portion, indeed, usually became so much larger when St Martin had lain for several hours on the left side,

* To the naked eye, the lining membrane of the stomach appears to secrete the gastric juice; but physiologists are now generally agreed that it is secreted by an immense number of minute glands, which are imbedded in the substance of the mucous membrane, and are scarcely recognisable without a strong magnifying power. According to Dr Sprott Boyd, the internal surface of the stomach, when examined with a lens, presents a number of polygonal depressions of a honeycomb appearance, of from one two-hundredth to one three-hundred-and-fiftieth of an inch in diameter, but larger near the pylorus. In the bottom of these depressions, numerous orifices are visible, which are the openings of perpendicular glands, gathered together in bundles, and which are fully supplied with capillary vessels from the arteries of the submucous tissue. The function of these glands is to secrete the gastric juice.—(See Kirke's Hand-Book of Physiology. London, 1848, p. 201.)

during sleep, as to spread over the neighbouring integuments five or six inches in circumference, fairly exhibiting the natural *rugæ* and mucous coat lining the gastric cavity. This appearance was almost invariably exhibited in the morning before rising from bed. Dr Beaumont found farther, that on pushing back the protruded part, and placing St Martin opposite to a strong light, the interior of the stomach became visible to a considerable extent.

Taking advantage of this fact, Dr Beaumont proceeded to examine, by means of a magnifying-glass, the changes which occurred on the introduction into the stomach of a well-masticated morsel of food, either through the external opening, or through the natural channel of the gullet. The moment the food came into contact with the villous coat, the action of the neighbouring bloodvessels increased, and their branches dilated so as to admit the red blood much more freely than before. The colour of the membrane consequently changed from a pale pink to a deep red, the vermicular or *wormlike* motions of the stomach became excited, and innumerable minute lucid points and very fine nervous and vascular papillæ could be seen arising from its surface. These papillæ distilled a pure, colourless, and slightly viscid fluid, which first collected in drops on the very points of the papillæ, and then trickled down the sides of the stomach till it mingled with the food. *This afterwards proved to be the gastric juice;* and the mucous fluid secreted by the follicles, which is found in the stomach in the absence of food, and which some have mistaken for it, not only is more viscid, but wants altogether the acid character by which gastric juice is always distinguished.

Gastric juice, in its purest form, and unmixed with any thing except the small portion of mucus from which it can never be obtained entirely free, is described by Dr Beaumont to be a clear, transparent fluid, without smell, slightly saltish (probably from the admixture of mucus), and very perceptibly acid. Its taste, he says, resembles that of thin mucilaginous water, slightly acidulated with muriatic acid. It is readily diffusible in water, wine, or spirits, and effervesces slightly with alkalies—a direct proof of its acid nature.

The grand distinguishing property of the gastric juice is the remarkable power which it possesses of dissolving or reducing to a soft, thickish, fluid mass, certain aliments submitted to its action. It acts with much greater energy upon animal than upon vegetable substances, and its most characteristic power may therefore be more strictly described as that of converting into a soluble form all *albuminous or protein articles of food*, whether these be derived from the animal or vegetable kingdom. The gastric juice thus acts with peculiar energy in dissolving flesh, eggs, and similar alimentary substances; while its action on potatoes, starch, and such articles, is comparatively feeble. The stomach, no doubt, has the power of reducing farinaceous substances, such as rice, and also well-boiled vegetables, to a pulp, and of dissolving and absorbing the albuminous principles which they contain; but the principal changes which vegetable aliment undergoes in digestion take place in the duodenum and the small intestines generally. When dextrine and sugar are detected in the stomach, as derived from starch, they probably owe their origin to the action of the saliva, as already explained; for the gastric juice does not appear to have any peculiar action on farinaceous substances, beyond exciting, after some time, acetous fermentation.

The gastric juice has no power over *living* animal matter. Had the case been otherwise, it would have at once attacked and destroyed the stomach itself which produces it. It is owing to this want of power over living animal matter, that certain worms are able to exist in the stomach of man and other animals; and, accordingly, if it were possible for an oyster, swallowed directly from the shell, to continue to live, it also would effectually resist every attempt at digestion. But it, in common with most other animals, soon perishes in circumstances so foreign to

its habits; and when once it is dead, the gastric juice assumes the mastery, and speedily converts it into chyme.

But although the gastric juice is thus unable to make any impression upon the living animal organism, its solvent action comes into play so immediately after life is extinguished, that when sudden death occurs soon after a meal, and the body is opened at the end of a few hours, erosion of the stomach itself is often found to have been produced by it. For a long time, such erosions were always considered to be the effects of poison; but they arise simply from the gastric juice, secreted for the digestion of the preceding meal exerting its solvent power upon the substance of the stomach, now unprotected by the principle of life, and therefore equally subject to the solvent action as any other portion of dead animal matter.

Another remarkable characteristic of the gastric juice is, that it exerts its solvent power only over organised, or, in other words, over animal and vegetable substances. No mineral or inorganic body can either undergo digestion, or afford nutriment to man or animals. Speaking in a general sense, vegetation accordingly seems to be a process for the conversion of inorganic matter into a proper nutriment for the support of animal life; and many species of animals seem in their turn to be little else than living organisms for the conversion of vegetable substances into a nutriment fit for other species by which they are intended to be devoured. This is obviously an intentional arrangement of Providence, to enable different classes of animals to co-exist and fulfil different destinies in the same sphere. For although it would have been easy for the Creator to bestow such a structure on all animals as to enable them to subsist entirely on vegetable aliment, the arrangement which He has seen fit to adopt, is the source of an infinitely greater amount of active enjoyment than what would otherwise have existed. Had there been no beasts of prey, the world would soon have been overrun with herbivorous creatures to such an extent, that their numbers would speedily have become excessive in reference to the possible supply of food, and there would have been infinitely more suffering from starvation and disease, than what actually arises out of the existing relation of different classes to each other. On the present plan, there is food and enjoyment for all; and when the time does arrive when one animal must become the prey of another, the deprivation of life is in most cases unforeseen, and the suffering which attends it is in general of only momentary duration. There is thus both enjoyment of life while it lasts, and a great additional field opened for the support of a large class of animals, which, with their present constitution, could not otherwise have continued in existence for a day.

Organized or *alimentary* substances, then, are *the only natural stimulants to the secretion of the gastric juice.* In their absence, no such secretion goes on; but the moment food touches the inner surface of the stomach, it begins. This happens, because food is the only foreign body which is intended by Nature to find its way into the stomach; and all bodies which are incapable of digestion are soon either rejected by vomiting, or expelled from the stomach into the bowel unchanged.

The sole purpose of the gastric juice being the conversion of food into chyme, the principle already referred to as demonstrated by Dr Beaumont —that in the natural state *its secretion never takes place unless on the actual contact of food*—appears so probable in itself, as scarcely to stand in need of proof. It is true that a temporary flow may be excited by the contact of the bulb of a thermometer or other indigestible body; but in such circumstances the secretion always ceases the moment the stomach has had time to perceive (so to speak) that no food is present. The same direct relation to food as the only proper stimulus, has been shewn by Dr John Reid, Longuet, and Blondlot, to hold with regard to all the functions of the stomach. When, for example, the attempt was made to

carry on digestion in animals by passing a galvanic current through the divided nerve, it always failed to excite either the muscular contractions of the stomach or the secretion of the gastric juice, unless some digestible substance —the natural stimulant—was also present. These, as Blondlot has remarked, are significant facts, and they throw light upon many discrepancies which have hitherto puzzled experimenters who were ignorant of them.

But while food is thus proved to be the only natural stimulus to the secretion of the gastric juice, it would be altogether erroneous to imagine that there is no limit to its production, and that, however much we may eat, the secretion will always be sufficient for digestion. On the contrary, Dr Beaumont has demonstrated not only that the gastric juice is secreted in limited quantity, but that *a given amount of it is capable of dissolving only a limited quantity of food*; and that, consequently, when we indulge to excess, a portion of the food must remain undigested, and subject to the ordinary laws of chemical decomposition from warmth and moisture; thus giving rise to the disengagement of air in the stomach, and the other well-known consequences of indigestion. This important fact was established by many conclusive experiments; but it will be sufficient to adduce one only. In every instance in which digestion had ceased, from the gastric juice being insufficient for the quantity of food to be acted upon, *the solvent action was immediately resumed on the addition of a fresh supply of the gastric juice*, although all other circumstances remained exactly the same. Nothing can shew more clearly than this, that indigestion must ensue when the quantity eaten exceeds in proportion that of the gastric juice which the stomach is capable of secreting at the time; and nothing can offer a more instructive warning to those who desire to escape the manifold miseries of dyspepsia. It is in vain, when we eat too much, to hope to coax the stomach to healthful digestion. For a few times, we may, with comparative impunity, stimulate it to higher action, and thus get rid of a heavier meal than we required; but continued indulgence in over-eating cannot be thus counteracted. The stimulus loses its power by its very repetition, and the temporary excitement to which it gives rise is procured only at the cost of more than proportionate debility when the stimulus is withdrawn. It is in this way that the most severe and protracted cases of indigestion are often produced, sometimes without any suspicion, on the part of the sufferer, of the cause of all his troubles.

As the stomach is not capable of secreting an indefinite quantity of gastric juice, and as a given amount can thus digest only a proportionate quantity of food, it becomes important, in a practical point of view, to determine the laws by which the secretion is regulated. Here, again, Dr Beaumont's experiments come to our aid with the revelation of a principle, which unexpectedly forced itself upon his attention in the course of his inquiry, till at length it assumed in his mind all the certainty of demonstration. It is, that, in the state of health, THE QUANTITY OF GASTRIC JUICE WHICH THE STOMACH IS CAPABLE OF SECRETING, ALWAYS BEARS A DIRECT RELATION TO THE AMOUNT OF SUSTENANCE REQUIRED BY THE SYSTEM AT THE TIME. Admitting the truth of this principle, and keeping in mind the close sympathy which exists between the stomach and the rest of the body, whereby uneasiness and a desire for food are immediately excited when the system is in want of nourishment, are we not farther warranted in inferring that, in the state of health, the strength of *the appetite* is the sign or indication by which the secreting power of the stomach may be pretty correctly estimated; and that, consequently, so long as we intelligently act in accordance with its dictates, we shall run little risk of eating more largely than the amount of gastric juice which the stomach is at the time capable of secreting will be found sufficient to digest? The known harmony which unites all the functions of the body, would of itself induce us to answer this question

in the affirmative; but, as we shall afterwards see, experience also leads directly to the same conclusions.

The relation thus shewn to exist between the state of the system and the secretion of the gastric juice, is farther illustrated by the modifications which the latter undergoes during disease. On this subject, the observations of Dr Beaumont are peculiarly instructive, because, instead of merely inferring, as others are obliged to do, he enjoyed the privilege of actually *seeing* what was going on. In the course of his attendance on St Martin, he found, for instance, that, *whenever a feverish state was induced* (whether from obstructed perspiration, from undue excitement by stimulating liquors, from overloading the stomach, or from fear, anger, or other mental emotion, depressing or disturbing the nervous system), *the villous coat became sometimes red and dry, and at other times pale and moist, and lost altogether its smooth and healthy appearance.* As a necessary consequence, the usual secretions became vitiated, impaired, or entirely suppressed; and the follicles from which, in health, the mucus which protects the tender surface of the villous coat is poured out, became flat and flaccid, and no longer yielded their usual bland secretion. The nervous and vascular papillæ, thus deprived of their defensive shield, were then subjected to undue irritation. When these diseased appearances were considerable, the system sympathised: dryness of the mouth, thirst, quickened pulse, and other symptoms, shewed themselves; and NO GASTRIC JUICE COULD BE PROCURED OR EXTRACTED, EVEN ON THE APPLICATION OF THE USUAL STIMULUS OF FOOD.

These facts are of extreme practical importance; and from the care with which Dr Beaumont pursued his investigations, and their accordance with the observations of preceding physiologists, I do not think their general accuracy can be called in question. The dry, irritated appearance of the villous coat, and the absence of the healthy gastric secretion, in the febrile state, not only explain at once the want of appetite, the nausea, and the uneasiness generally felt in the region of the stomach, but shew the folly of attempting to sustain strength by forcing the patient to eat when food cannot be digested, and when Nature instinctively refuses to receive it.

Before dismissing this part of the subject, I may remark that the alleged sympathy of the stomach with the wants of the body has been denied, because the sensation of hunger ceases the moment food is swallowed or the stomach distended even with clay or saw-dust, although the actual wants of the system cannot have been supplied in either case. But these facts seem to me rather to justify the inference that a sympathy does exist. Hunger ceases when *food* is taken, simply because *now* the condition of the stomach is in the desired relation to the state of the body, and the nerves transmit a corresponding impression to the more distant parts. In the other case, again, it ceases because the stomach cannot, at first, distinguish what is food from what is not, and therefore, when distended, expresses content, because it feels satisfied that it has been honestly dealt with, and got what it wanted. But whenever it discovers the cheat, which it does in no long time, hunger returns, and can be properly appeased only by digestible substances. In further accordance with this principle, it appears from Dr Beaumont's observations, that although the gastric secretion *commences* the moment any indigestible body touches the mucous surface of the stomach, it invariably *ceases* soon after the substance is discovered to be one over which the gastric juice has no power.

Many attempts have been made to ascertain to which of the elements of the gastric juice its power is chiefly to be ascribed, and experiments have been instituted on them individually to discover which of them is most nearly analogous to it in effect. From the general results, it appears that gastric juice owes its solvent qualities to a peculiar animal principle, which has received the name of *pepsin*, and to the presence of a free acid. Pepsin is the

peculiar product of the minute glands of the mucous coat of the stomach, but it occurs likewise in the small and large intestines, though in the last its quantity is very minute. It is to pepsin that the stomach of the calf owes its power of coagulating milk, which process is thus as it were the commencement of digestion. Pepsin alone is incapable of forming chyme; a free acid must likewise be present; but physiologists are not yet agreed as to the nature of the acid of the stomach. By many it is considered to be muriatic acid, by some acetic acid, and by others lactic acid; and reasons of considerable weight may be adduced in support of each opinion, for all those acids act equally well in experiments on artificial digestion. Muriatic acid may undoubtedly be obtained from the gastric juice by distillation; but Valentin, one of the most able physiologists of the day, is inclined to regard it as the result of decomposition at a high temperature, or of altered chemical affinity from concentration; and thinks it unlikely that Nature, who generally works with the mildest materials, would call in the assistance of an uncombined powerful mineral acid. He is in favour of lactic acid, but acknowledges that there are no positive facts to support this preference.* The recent discovery, however, by Liebig, of large quantities of free lactic acid in the juices of the body, gives considerable weight to Valentin's views. But without farther discussing the question, I may here remind the reader of the well-known solvent power of acetic acid; the existence of which explains, in some measure, the general use of vinegar along with salads, cucumbers, oysters, salmon, and other substances of difficult digestion, and shews that its utility is not imaginary, but is confirmed by the analogy of Nature's own acts.

Various theories have been invented to explain the phenomena of digestion. Hippocrates regarded it as a kind of *concoction* or *stewing*, and many of his followers believed it to be effected in the stomach by the agency of heat alone, much in the same way as food is cooked over a fire. It is quite ascertained that heat favours the process, but it would be pure absurdity to maintain that that agent alone will accomplish digestion.

Others of the older physiologists contend that chymification results from simple *fermentation* of the alimentary mass, and refer to the gas disengaged during difficult digestion, as a proof that the process of fermentation goes on. But it is now demonstrated, that the tendency of healthy digestion is rather to arrest than to induce fermentation, and that the latter takes place only when disease exists, or when more food has been swallowed than the quantity of gastric juice secreted by the stomach is able to dissolve. Moreover, the products of digestion and fermentation are so extremely different, that it is impossible to believe them to originate from the same chemical action.

The next theory which prevailed, considered digestion to be the result of the *putrefactive* process. The single fact that the gastric juice not only arrests putrefaction, but even restores to sweetness meat in which that process is begun, is sufficient to demonstrate the wildness of such a supposition.

Another set of physiologists imagined that *trituration* would account best for all the changes occurring in the food during digestion; and, consequently, regarded the chyme as a sort of emulsion formed by the intimate mixture of the aliment with the juices of the stomach, just as an emulsion is made by rubbing down almonds in a mortar. The advocates of this theory referred for proofs not only to the contractile motions of the stomach, already noticed, but to the muscular apparatus for trituration, which forms so remarkable a feature in the gizzard of granivorous birds. But, in adopting this conclusion, they forgot that, in birds, the triturating apparatus does not digest, but serves, like the organs of mastication in man and quadrupeds, merely to bruise the grain on which the animal lives. The truth is, that in birds, digestion *begins* only *after* the trituration is finished.

* Lehrbuch der Physiologie vol. i., p. 312.

The most recent and accurate theory of digestion is that advocated by Valentin, and most other modern physiologists, and which considers it to consist essentially in a solution of the food in the gastric juice; which solution may be said to be at first purely chemical, but is extended by the changes induced by contact, on the same principle as the action of yeast extends to a large mass of dough. Pepsin is thus supposed to act like diastase;* but a certain quantity of it can effect the solution of only a definite quantity of food. This theory of digestion has been objected to as too exclusive, but it is, unquestionably, supported by a greater number of facts and experiments than any other; and there cannot be a doubt, that, by the combined agency of heat and gastric juice on food out of the body, a change can be effected in it very similiar to, if not identical with, chymification. At the same time, when we consider the variety of substances which are converted into chyme by the agency of the same fluid, we shall be more inclined to believe digestion to be something more than a mere chemical solution, or, at least, such a solution as art can imitate by chemical means. Accordingly, the vital principle has, by many, been supposed to exercise a predominant influence in the production of the results. All the direct evidence, however, tends to negative this latter supposition; for, in proportion as our knowledge extends, the recognised sphere of operation of the vital principle, as an abstract power, becomes more and more limited, and that of the physical laws of nature more and more extended. From a careful review of the phenomena, the legitimate inference seems to be, that the muscular motions and organic nutrition of the stomach, and the secretion of the gastric juice, are directly under the influence of the vital principle, but that with the production of these phenomena that influence wholly ceases, in so far that the gastric juice, once secreted and mixed with the food, continues to act after life is extinguished exactly as it did before, and with similar results. This could not happen if any strictly vital force were essential to its action as a solvent of the food. But, in order to form a correct idea of the process of digestion, we must, as already stated, look upon it as a complicated process which varies with the nature of the food. The nearer the food approaches in constitution to the blood, the more simple does digestion become; and little else is wanted than mere solution and absorption to convert a meal of flesh or albumen into blood. But the process becomes more complicated when a meal of potatoes or bread is to be digested; and the chyme which results from a meal of this kind, is very different in composition from that which is derived from a meal of flesh.

* *Vide ante*, p. 19.

To enable the reader to form his own opinion of the nature of the changes which occur during digestion, it will be useful to take a brief survey of the results of numerous experiments performed by Spallanzani, Stevens, Beaumont, and others, on the action of the gastric juice on food out of the body, when, of course, all the phenomena were visible.

Various methods have been employed for procuring gastric juice in a state of purity for experimental purposes. Pieces of dry sponge, inclosed in a small, hollow, perforated ball, with a string attached to it, have been swallowed both by man and by inferior animals, and afterwards withdrawn to have the juice expressed from them. In some instances the stomachs of criminals and animals killed after fasting have been opened, and the secretion collected. At other times the juice has been procured by voluntary or artificial vomiting. Of these three methods, the first is unquestionably the best; because, although no gastric juice previously exists, the contact of the ball generally succeeds in exciting the secretion of a quantity sufficient to moisten the sponge. In the second mode of proceeding, any portion of juice secreted in consequence of a stimulus applied *after* death, must necessarily be very small, and be rendered impure by the

large admixture of mucus which the stomach will contain; while, by the third method, as the gastric juice does not exist ready-made in the stomach, either mucus alone will be procured, or the required fluid will be expelled, mixed with the food or substance which previously elicited its secretion.

The facilities presented by the case of St Martin gave Dr Beaumont great advantages over other experimenters in procuring gastric juice in a state of purity almost at will, and, consequently, in ascertaining its properties and mode of action both in and out of the stomach. From his work, therefore, the following statements are chiefly taken.

To ascertain the nature of the solvent action ascribed to the gastric juice, Dr Beaumont withdrew from St Martin's stomach about *one ounce* of it, obtained after a seventeen hours' fast, by introducing first a thermometer to induce the secretion, and then a gum-elastic tube to carry the fluid off. Into this quantity, placed in a vial, he introduced a piece of boiled recently-salted beef, weighing *three drachms*. He then corked the vial tightly, and immersed it in water raised to the temperature of 100°, which he had previously ascertained to be the heat of the stomach when the secretion was going on. In *forty minutes*, digestion had distinctly commenced on the surface of the beef. In *fifty minutes*, the fluid became quite opaque and cloudy, and the texture of the beef began to loosen and separate. In *sixty minutes*, chyme began to be formed. In *one hour and a half*, the muscular fibres hung loose and unconnected, and floated about in shreds. In *three hours*, they had diminished about one-half. In *five hours*, only a few remained undissolved. In *seven hours*, the muscular texture was no longer apparent; and in *nine hours* the solution was completed. In all respects these results agree with those obtained by Spallanzani many years ago.

To compare the progress of digestion in the natural way with the above changes, Dr Beaumont, at the time of commencing the experiment just described, suspended a piece of the same beef, of equal weight and size, within the stomach by means of a string. At the end of the *first half hour* it presented the same appearances as the piece in the vial; but when Dr Beaumont drew out the string at the end of *an hour and a half*, the beef had been completely digested and had disappeared, making a difference of result in point of time, between natural and artificial digestion, of nearly seven hours. In both experiments the solution began on the surface, where, of course, the contact of the gastric juice was most direct; and agitation accelerated its progress by removing the external coating of chyme as fast as it was formed. When the experiment was repeated with chicken instead of beef, the solution was slower, from the greater compactness of the chicken not allowing the gastric fluid to penetrate its substance so readily. Had the beef and chicken been masticated before being subjected to experiment, the difference between them in the rapidity of digestion would probably have been less.

To discover still more accurately the difference between natural and artificial digestion (the one *in* and the other *out of* the stomach), Dr Beaumont put *twelve drachms* of boiled recently-salted beef into a vial, with *twelve drachms* of fresh gastric juice obtained through the opening of the stomach after a fast of eighteen hours; and then placed the vial in a basin of water on a sand-bath, where he kept it at the heat of 100° Fahr., and continued to agitate it gently. Digestion soon commenced, and went on uniformly for about six hours, when it ceased. One-half of the meat was then dissolved, and the texture of the remainder was loosened and tender,—resembling the same kind of aliment when ejected from the stomach partly digested, some hours after a meal, as frequently seen in cases of indigestion. On weighing the undissolved portion which remained after all action had ceased, six drachms and twelve grains of the beef were found to have been digested by twelve drachms, or nearly

double its weight, of gastric juice. These results afford an additional confirmation of the solvent power of the gastric juice being limited in amount; so that, when more is eaten than the stomach can secrete juice to dissolve, indigestion must inevitably follow.

To vary the experiment, and ascertain what influence would be exerted on food masticated, swallowed, and mixed with the gastric juice in the usual way, and then withdrawn from the stomach, Dr Beaumont gave St Martin an ordinary dinner of boiled salted beef, bread, potatoes, and turnips, with a gill of pure water for drink; and twenty minutes afterwards drew off through the opening about a gill of the contents of the stomach into an open-mouthed vial. In this short space of time digestion had already commenced, thus negativing the vulgar notion that an hour elapses before it begins. The vial was now placed in a water-bath, at a temperature of 100°, and continued there for five hours. Examined at the end of that time, the whole contents were found to be dissolved. On then extracting an equal quantity of chyme from the stomach, and comparing it with the solution in the vial, little difference was observable between them, except that the process had been somewhat more rapid in than out of the stomach. But this experiment is remarkable in another point of view, as shewing that, *in the short space of twenty minutes, enough of gastric juice had been secreted for the entire completion of digestion.*

With a view to verify these results, and also to discover the comparative digestibility of different kinds of aliment, Dr Beaumont gave St Martin for dinner eight ounces of *recently-salted lean beef*, four ounces of *potatoes*, some *bread*, and four ounces of boiled *turnips*. After fifteen minutes he withdrew a portion of the contents of the stomach, and found that some of the meat had already been slightly digested. In a second portion, withdrawn at the end of forty-five minutes, fragments of the beef and bread were perceptible, and in a still more advanced state of digestion; the meat was in small shreds, soft and pulpy, and the fluid containing it had become more opaque and gruel-like in appearance. When two hours had elapsed, a third quantity was taken out, at which time nearly all the meat had become chymified and changed into a reddish-brown fluid; but *small pieces of vegetable matter now presented themselves for the first time, but in a state of digestion so much less advanced* than the meat, that their peculiar structure was still distinctly visible. Some of the second and third portions, put into a vial and treated in the usual way, advanced to complete digestion, as in the other experiment, except that the process was slower, and that a few vegetable fibres remained to the last undissolved; thus confirming the general opinion that vegetables are more difficult of digestion than animal substances.

The gastric juice being thus the active agent in chymification, it follows, as a matter of course, that it must be brought into direct contact with every particle of the food on which it is destined to act, otherwise the unmixed portion will remain undigested. This requisite admixture of the gastric juice with the food is effected by the muscular contractions of the stomach, aided by the previous preparation of the morsel during mastication. On placing a small piece of meat in a vial, with an adequate quantity of gastric juice at the temperature of 100°, the solvent action immediately began, and in a short time the meat was covered with a layer of chyme. If the vial was then gently shaken so as to remove the dissolved portion and expose a new surface to the fluid, the solution went on as rapidly as before. But if the vial was left unmoved, and the layer of chyme permitted to remain, the access of the gastric juice to the surface below became impeded, and, as a consequence, the progress of the solution was greatly retarded. For precisely the same reason, meat chopped into small pieces was much sooner dissolved than when immersed entire in the gastric juice. Similar results were obtained when the experiment was made in St Martin's stomach instead of

a vial. When, for instance, two ounces of unmasticated roasted beef were introduced through the external aperture into the stomach, and held by a string, only one half of it was digested in four hours, evidently from the want of mastication confining the action of the gastric juice to the surface of the mass, and from the string preventing the dissolved portion from being rubbed off by the muscular contractions of the stomach.

Here, then, we perceive a direct and important purpose fulfilled by the muscular coat of the stomach; but indirectly it is also useful in *presenting an impediment to the too rapid or excessive distention of the stomach.* Dr Beaumont observed, that, in the natural state of that organ, a regular and gentle contraction of its whole fibres and cavity ensued on the introduction of each individual morsel, and that it is not till the relaxation subsequent to that contraction has taken place, that another is willingly admitted. In like manner, when the valve in St Martin's stomach was depressed, and a few spoonfuls of soup were introduced at the orifice, Dr Beaumont observed the rugæ or folds of the mucous membrane to close gently upon it, gradually diffusing it through the gastric cavity, and completely preventing the entrance of a second quantity till this diffusion was effected—when relaxation again took place, and admitted of a farther supply. When solid food was introduced in the same way, either in large pieces or finely divided, the same gentle contraction and grasping motion were excited, and continued from fifty to eighty seconds, so as to prevent more from being introduced without considerable force till the contraction was at an end. When St Martin was so placed as to admit of the upper orifice of the stomach being brought into view, and was then made to swallow a morsel of food in the natural way, a similar contraction of the stomach, and closing of its fibres upon the bolus, was invariably observed to take place; and till this was over, a second morsel could not be received without a considerable effort. This arrangement was more than suspected by other physiologists, but it remained for Dr Beaumont to demonstrate its existence, and its use as an impediment to the too rapid or excessive distention of the stomach by solid food. It is true that, during a hurried repast, for example, food *may* be rapidly introduced into the stomach by an active effort of the will; but it is precisely in such circumstances that we are apt to eat too much, and that indigestion follows from no time being allowed for the secretion of the requisite quantity of gastric juice, and its proper mixture with each portion of the aliment. And accordingly, when, either from haste or hunger, we disregard the order of Nature, and hurriedly gulp down food without due mastication, and without allowing time for the regular contraction of the stomach, we necessarily expose ourselves to the risk both of overloading it, and of ultimately impairing its digestive power.

The muscular fibres of the stomach being thus acted upon by their appropriate stimulus, the particles of the food are made continually to change their place; and if the quantity eaten be not too great in proportion to the gastric juice which the stomach can supply, chymification goes on so equally throughout, that if the contents of the stomach be withdrawn in from thirty minutes to an hour after a moderate meal, they will be found to consist of perfectly-formed chyme and particles of food, intimately mixed and blended, in larger or smaller proportions, according to the vigorous or enfeebled state of the digestive organs, and the quality of the aliment itself. So effectually, indeed, has the admixture of food and solvent juice taken place in this short time, that, as already shewn, when a portion of the contents of the stomach is removed and placed in an appropriate vessel, digestion will commonly continue in it, provided it be placed in a proper temperature, and subjected to gentle and continued agitation.

The impossibility of its being adequately acted upon by the muscular contractions of the stomach, is one of

the reasons why fluid and highly concentrated nourishment, when exclusively used, is so difficult of digestion; and why a certain bulk and consistence given to whale-oil, for example, by the admixture of such innutritious substances as vegetable fibre, bran, or even sawdust, make it a more acceptable and digestible article of food to the inhabitants of the northern regions, than when it is consumed in its pure state. In like manner, in civilised society, bread, potatoes, and vegetables, are useful, not less by giving the requisite bulk and consistence to the rest of the food, than by the nutriment which they contain. Soups, jellies, arrow-root, and similar substances, are, for this reason, more easily digested when eaten along with bread or some bulkier aliment, than when taken alone, especially if used for some time.

The motion excited in the stomach by the entrance of aliment, is at first gentle and slight, but becomes more rapid and energetic as digestion proceeds, and then serves the additional purpose of gradually propelling the chyme through the pylorus into the intestine, there to be farther prepared and converted into chyle. From the peculiar situation of the stomach, this necessary churning or agitation of the food is greatly assisted by the play of the diaphragm and abdominal muscles during inspiration and expiration; and the diminution of the vivacity and extent of the respiratory movements which always attends despondency and grief, is one source of the enfeebled digestion which notoriously accompanies or follows depression of mind. The same cause also leads necessarily to deficient nervous stimulus and an unfavourable condition of the blood itself, which in their turn weaken digestion in common with every other function; but the muscular or mechanical influence is that which at present chiefly concerns us. On the other hand, the active and energetic respiration attendant on cheerfulness and buoyancy of spirits, adds to the power of digestion, both by aiding the motions of the stomach, and by imparting to it a more richly constituted blood. If to these causes be added the increase of nervous stimulus which pleasing emotions occasion in the stomach (as in the muscles, and organs of secretion generally), we shall have no difficulty in perceiving why digestion goes on so well in parties where jocularity and mirth abound. "Laughter," says Professor Hufeland of Berlin, "is one of the greatest helps to digestion with which I am acquainted; and the custom prevalent among our forefathers, of exciting it at table by jesters and buffoons, was founded on true medical principles. In a word, endeavour to have cheerful and merry companions at your meals; what nourishment one receives amidst mirth and jollity will certainly produce good and light blood."

Great, however, as the solvent power of the gastric juice is, *it requires the aid of heat* to enable it to act with effect on any kind of food. To test this point, Dr Beaumont took out two ounces of gastric juice, and divided it into two equal portions, in separate vials. He added to each an equal weight of masticated fresh beef; and placed the one in a bath at the temperature of 99°, being that of the human body, and the other in the open air at 34°. As a contrast to these, he placed beside the latter a third vial, containing the same weight of masticated meat in an ounce of clear water.

In two hours the meat in the warm vial was partially digested; while that in the cold gastric juice was scarcely at all changed; and the third portion, in the cold water, seemed only a little macerated. In six hours the meat in the warm vial was half digested, whereas that in the two others had undergone no farther alteration. The gastric juice in the first vial having by this time dissolved as much as it could of the beef, four drachms more were added from the stomach, and the vial was replaced in the bath. *Digestion, which had previously ceased, was now resumed, and went on as steadily as if it had not been interrupted.*

At the end of twenty-four hours, the three portions were examined. That contained in the warm juice was completely dissolved, and presented the

usual appearances. The portions contained in the cold juice and in the cold water very much resembled each other, and *exhibited no appearance whatever of chyme.* They were macerated or softened, but not digested. These experiments, and others of a similar nature, shew clearly that a temperature equal to ordinary blood-heat is requisite for chymification, and also strikingly confirm the principle that healthy digestion depends greatly on our not eating more than the due proportion to the quantity of gastric juice which the stomach is capable of secreting.

To make sure that it was the low temperature alone which prevented the occurrence of digestion in the preceding experiment, Dr Beaumont now placed, on a water-bath at the ordinary blood-heat, the vial containing the meat which had been exposed without effect for twenty hours to the action of the cold gastric juice. In a very short time "digestion commenced, and advanced regularly as in the other parcels." The same results were always obtained from a repetition of these experiments, so that they may be held as perfectly conclusive in demonstrating the essentiality of heat to the digestive process. Common observation, indeed, establishes this truth. Dr Kitchiner, for example, after stating that "a certain degree of heat is absolutely necessary to excite and support a regular process of digestion," remarks that, "when the circulation is languid and the food difficult of solution in aged persons and invalids, even *external* heat will considerably assist concoction, and the application of the calefacient concave (stomach warmer) will enable the digestive organs to overcome refractory materials, and convert them into laudable chyle."

Exposed, then, as the food is to the action of all the agents above enumerated, and to the increased nervous and vascular excitement which occurs during digestion, a singular change quickly commences in it, and goes on till chymification is completed. Soon after being swallowed, the contents of the stomach, whatever their nature and variety, begin, if capable of gastric digestion, to be converted into a substance of a soft, greyish, and viscid appearance, and of a sweetish, *fade*, and slightly-acid taste, but which still preserves some of the qualities of the food, and is called chyme. The chyme always forms on that part of the food with which the gastric juice is in immediate contact; and, in proportion as it is produced, it is carried gradually onwards by the gentle motion of the stomach towards the pylorus, where, consequently, it always exists in the greatest quantity. On its arrival there, the pylorus, or valve between the stomach and the intestine called the *duodenum*, opens and allows the chyme to pass into the bowel, along with those parts of the food which resist, either partially or altogether, the action of the gastric juice. We shall afterwards see reason to think that many vegetable substances pass the pylorus in an early stage of digestion, having been scarcely attacked by the gastric juice; and that physiologists have erred greatly in ascribing their disappearance from the stomach to their quick digestion. Indeed it seems probable, from the researches of Bouchardat and Sandras, that the chyme which passes the pylorus is principally that part which requires to be submitted to the action of the bile and pancreatic juice for its further digestion; and that the albuminous portion of the chyme, which is capable of direct assimilation, is absorbed directly by the vessels of the stomach.

Chyme was long supposed to be of exactly the same nature, from whatever kind of food it was formed. Magendie has dispelled that error, and shewn that it varies even in colour, consistence, and appearance, with every change of diet. This result may be easily verified by feeding dogs on different kinds of food, and inspecting the stomach immediately after they are put to death. On several occasions, Magendie was enabled to verify it also in man, by inspecting the bodies of criminals executed soon after being fed.

The solvent action of the gastric juice upon alimentary substances being

thus established, the question naturally occurs, Does the gastric fluid produce exactly the same changes on all kinds of food, or does its mode of operation vary according to their different constitutions and properties? To a certain extent this question is answered in the extracts already given from the work of Dr Beaumont, but it has been still more satisfactorily settled by the experiments of Blondlot. That the mode of action of the gastric juice is not identical in all cases, is shewn by its palpably different effects on meat and on milk, for example; for while it gradually reduces meat and other solid aliments to a soft and fluid state, its first effect on milk is to coagulate it and render it firm and consistent. Fifteen minutes after St Martin had drunk half a pint of milk, a portion of it taken out of the stomach by Dr Beaumont presented the appearance of a fine, loosely-coagulated substance, mixed with a semi-transparent whey-coloured fluid. A drachm of warm gastric juice poured into two drachms of milk, at a temperature of 100°, produced a precisely similar appearance in twenty minutes. In another experiment, when four ounces of bread were given along with a pint of milk, and the contents were examined at the end of thirty minutes, the milk was coagulated, and the bread reduced to a soft pulp floating in a large proportion of fluid. In two hours the whole was digested.

According to Dr Beaumont, coagulation is also the first effect produced on albumen or the white of egg in the raw state; but Blondlot disputes the accuracy of this observation, and affirms that, in the course of many experiments on dogs, he never saw even an approach to coagulation take place. On the contrary, the albumen in every instance passed through the stomach unaltered, and was found in the intestine in its fluid state. As Blondlot's experiments were numerous and carefully conducted, and Dr Beaumont speaks of only one observation, I am inclined to concur with Blondlot in believing that Dr Beaumont had been deceived by some accidental appearance resembling the commencement of coagulation, and that in reality no such change occurred. Whether it did or not, however, it equally shews that the gastric juice does not act in the same way on all alimentary substances; which is the only point at present under discussion.

In the case of liquid food, again, another variety of action is observed. When soup, for example, is taken either alone or in large proportion, the more fluid part is speedily absorbed, and the remaining nutritious portion is then better fitted for being acted on by the gastric juice and muscular power of the stomach; but in impaired digestion, the requisite absorption of the fluid part does not go on so rapidly. Fifty minutes after St Martin had dined on vegetable soup, beef, and bread, Dr Beaumont found the stomach to contain a pulpy mass, like thick gruel in consistence, and of a semi-gelatinous aspect. The fluid portion had been absorbed to such an extent, that the remainder was even thicker than is usual after eating more solid food. From many similar observations, Dr Beaumont infers it to be a general law, that soups and liquids cannot be digested till they are formed into a thicker mass by the absorption of their watery part—as till then they are too liquid to be easily acted on by the stomach. Hence their unfitness for dyspeptic invalids, and the impropriety of large draughts of tea or coffee at breakfast in such cases. The gastric juice is thus rendered too dilute and unfit to promote the healthy digestion of albuminous bodies, while farinaceous substances easily pass into acetous fermentation. In robust health, the stomach readily absorbs the superabundant fluid; but in many states of the system the blood is already overloaded with water, and absorption takes place very slowly.* During recovery from illnesses, chicken-tea, beef-tea, and soups are often useful, because the system then requires the liquid to make up its lost blood. They ought always, however, to be made very weak at first, and to be given in small quanti-

* See the remarks on p. 29.

ties. If these rules be observed, they are readily absorbed, and the animal extract which they contain passes directly into the blood, affording immediate nourishment. But if, on the contrary, they are too concentrated, and contain in solution a larger amount of animal matter than exists in the serum of the blood, absorption proceeds slowly, and the stomach is readily oppressed. We shall afterwards see that fat and oils resist the action of the gastric juice. Hence the necessity of freeing the soups of invalids from every vestige of fat; for otherwise it lies upon the stomach for hours, giving rise to great discomfort, and sometimes even becoming rancid.

Unfortunately, Dr Beaumont made but few experiments on the action of gastric juice upon vegetables; and, in the few recorded, he usually contents himself with noting the length of time required for their solution, which generally proved considerably longer than for animal substances. In one experiment, however, he states that, an hour after giving St Martin nine ounces of *raw, ripe, sour apples*, the stomach was full of fluid and pulp, "quite acrid, and irritating the edges of the aperture, *as is always the case when he eats acescent fruits or vegetables.*" In an hour and a half the contents were still more sharp and acrid, and the pulp of the apple was visible. At the end of two hours the stomach was empty, but the mucous membrane exhibited an irritated appearance. With farinaceous vegetables, however, the results were different. Thus, when a pint of thick, rich, boiled sago, sweetened with sugar, was given, the whole was digested in less than two hours, and there was neither acrimony of the gastric contents, nor smarting of the edges of the wound; on the contrary, the food seemed peculiarly grateful to the stomach, and rendered the mucous membrane soft, uniform, and healthy. The same results followed a repetition of the experiment, and also the taking of a pint of soft custard. In some states of the stomach, however, even farinaceous food becomes acrid and irritating, although rarely in the same degree as the other forms of vegetable aliment.

Before leaving this part of the subject, it may be proper to mention shortly the general conclusions arrived at by Blondlot regarding the action exerted by the gastric secretion on different kinds of food. From a series of carefully-conducted experiments, he was led to infer, 1*st*, That on that class of aliments which includes mucus, resins, fecula, and the ligneous fibre of vegetables, the gastric juice produces exactly the same effects as would arise from the combined influence of heat, moisture, and minute division of parts: 2*dly*, That on liquid albumen, sugar, gum, starch, pectine, and such other principles as are soluble in water, it acts precisely as water itself would do, and dissolves them, without altering their nature: And, 3*dly*, That on the class of aliments which includes fibrine, coagulated albumen, caseine, gelatine, and some parts of succulent vegetables, it exercises no solvent power properly so called, but merely destroys, to such a degree, the power of cohesion which unites their component atoms, that, on the slightest agitation, they become diffused through the fluid in the form of molecules of the smallest size, but without undergoing farther change. On some of the alimentary principles belonging to this class, acidulated water was observed by Blondlot to produce precisely the same effects; but, in the case of the animal principles above mentioned, and a few others, the mode of action could not be accurately imitated by any known chemical agent, and was, consequently, held by Blondlot to be *of a special kind*, and characteristic of the gastric juice alone. It is worthy of remark, also, that this special action is limited to precisely that class of alimentary substances which are most rich in nutriment, and which are also all *isomeric;* that is to say, which, however different they may be in their appearance and properties, are all compounds of the same elements in the same proportions—and of these nitrogen is the most important. They form the protein compounds mentioned above, p. 14.

This peculiarity of action, as distinct from mere solution, is very well exemplified in gelatine. When gelatine is submitted to the action of the gastric juice, its constituent particles not only become completely diffused through it, but lose their cohesive power so entirely, that, on cooling, the gelatine remains perfectly fluid, and can no longer form a jelly, which it always does on cooling after being merely dissolved. No other change of composition, however, can be detected in it.

To shew the distinction which really exists between the mode of action of the gastric juice and that of acidulated water on the alimentary substances in question, Blondlot took two pieces of boiled meat of the same size and form, and put the one into a vial with gastric juice, and the other into a vial of acidulated water, as the solvent which most nearly resembles it. To supply the requisite heat, he then placed both of them for twelve hours in a bath at the temperature of 99°, carefully avoiding the slightest agitation of their contents. At the end of that time the most experienced eye could not, he says, detect any difference whatever between the two pieces of meat, or the two portions of liquid; but the moment the contents were stirred with a glass rod, the meat in the gastric juice crumbled down into a kind of pulpy matter of uniform consistence, and formed of molecules so minute that, even with the aid of the microscope, no trace of organization could be detected in them. The meat in the acidulated water, on the other hand, preserved its firmness and organic structure, and was only somewhat softened.*

Another striking and unexpected proof of the gastric juice being a fluid strictly *sui generis*, is the singular effect of a slight rise of temperature in wholly destroying its activity. For the demonstration of this fact also we are indebted to Blondlot, and it is one of the most remarkable which he has elicited. He states, that he satisfied himself by numerous experiments, that the mere elevation of temperature from 99° to 115° or 120° is sufficient to destroy wholly and irrevocably its digestive power, although, on the most careful examination, no change whatever in its appearance or chemical constitution can be detected, and the ablest chemist cannot distinguish a portion of gastric juice so changed, from one taken fresh from the stomach! (P. 358.) This result seems the more extraordinary, when it is recollected that the same fluid may be not only cooled, but actually frozen, and again thawed, without impairment of its active properties, provided its natural heat be restored very gradually.

Gastric juice which has been heated to 120°, and has thus lost its activity, nevertheless *retains all its acid properties*. This fact shews clearly that chymification must be something more than a mere solution of the food in acidulated water, as some physiologists contend.

A liquor possessing all the properties of the gastric juice, may be prepared by infusing a portion of the mucous coat of the stomach in water, and adding a few drops of muriatic or acetic acid. The animal principle which, as mentioned on page 48, has received the name of *pepsin*, resides in the mucous membrane, probably in its minute follicles, from which no washing can remove it. When a portion of gastric mucous membrane is infused in water, and some small pieces of meat are introduced, no solution takes place till a little acid be added. The changes which then ensue are precisely similar to those produced by the gastric juice itself. The proper quantity of acid is from three to six grains to two drachms of liquor: a smaller quantity of acid is not sufficient to accomplish digestion, and a larger quantity weakens or altogether destroys the digestive power. This observation by Schwann, explains how excess of acid in the stomach is prejudicial to digestion. The gastric solution is, in so far, to be compared with the phenomena of fermentation, that a very minute quantity of the digestive principle suffices to produce solution. Thus, Schwann found that 4·8 grains of digestive liquor, containing only 0·11

* Blondlot Traité de la Digestion, &c., p. 343.

grain of dry digestive principle, was sufficient to cause the solution of 60 grains of coagulated white of egg, equal to about 10 grains of dry albumen.* Pepsin, therefore, is an animal diastase, a minute portion of which is sufficient to enable protein compounds to assume a different shape. In doing so, however, they undergo no decomposition, but merely a metamorphosis, retaining the same chemical elements. The changes which the artificial digestive liquor produces on starch, potatoes, sugar, fat, and other non-nitrogenous articles of diet, apparently are not owing to any specific action of the liquor, but are the results of ordinary chemical laws; so that the experiments with this artificial liquor give support to the opinion, that the action of the gastric juice as a digestive solvent is limited to the protein compounds. The digestive liquor may also be prepared from the mucous membrane of the small and large intestines; but when obtained from the large intestines, its solvent powers are much weaker than when procured from the small intestines or stomach. This fact, however, points to the inference, that the protein compounds may undergo digestion, to a certain extent, throughout the whole course of the alimentary canal.

Before concluding his inquiry, Dr Beaumont made many observations with a view to ascertain whether any increase of temperature occurs during digestion. By introducing a thermometer with a long stem into St Martin's stomach, both before and during chymification, he succeeded in obtaining very accurate information on this point. In two or three of the experiments the heat of the stomach seemed to be increased after taking food, but in by far the greater number the temperature remained the same. It appears, however, that the variations of the weather produce a sensible effect —a dry air increasing, and a moist air diminishing the heat of the stomach. The ordinary temperature may be estimated at 100° Fahr., and in several instances it was higher at the pyloric than at the cardiac end. On one cloudy, damp, and rainy day, the thermometer rose only to 94°, and on another to 96°; whereas next day, when the weather was clear and dry, it rose to 99°, and on that following, when the weather was both clear and cold, to 100°. On several occasions it rose as high as 102°, and once to 103°; but these were after exercise, which was always observed to cause an increase of two or three degrees. We have already seen that *artificial* digestion is entirely arrested by cold, and is resumed on raising the temperature to the ordinary blood-heat.

Such, then, are the phenomena and conditions of healthy digestion, on which I have dwelt perhaps at greater length than was strictly required in a work written expressly for popular and practical purposes. My objects in venturing upon such detail, even at the risk of being considered tedious, were chiefly to shew the reader, as far as lay in my power, *a foundation in nature and reason* for the dietetic principles which will shortly be submitted to his consideration; but partly also to gratify the natural and rational curiosity which every enlightened mind must feel to become better acquainted with the wonderful operations of the animal economy, and to trace, in the unity and harmony of design which are apparent in even their minutest arrangements, the most unequivocal evidences of the omniscient foresight and beneficence of God.

Without considerable details, and some repetition, neither of these objects could have been fully accomplished; because, to most unscientific readers, the subject is so new, that a bare outline of the leading facts regarding the nature and laws of digestion would have been either wholly unintelligible, or of too little interest to lay hold on the attention. For the same reason it may be useful to subjoin here a brief summary of the principal inferences deduced by Dr Beaumont from his numerous experiments and investigations. In doing so I shall attempt to arrange the results in their natural order; for in the original

* Muller's Physiology, French edit., vol. i., p. 451.

work they are given without reference either to time or to the relation between cause and effect.

INFERENCES FROM DR BEAUMONT'S EXPERIMENTS AND OBSERVATIONS.*

1. That *hunger* is the effect of *distention* of the vessels that secrete the gastric juice. (This inference is a mere hypothesis, which cannot by any means be received as proved.—J. C.)
2. That the processes of *mastication, insalivation,* and *deglutition,* in an abstract point of view, do not in any way affect the digestion of the food; or, in other words, when food is introduced directly into the stomach in a finely-divided state, without these previous steps, it is as readily and as perfectly digested as when they have been taken. (This inference is too sweeping, and ought to be confined to animal food.—J. C.)
3. That *saliva* does not possess the properties of an alimentary solvent. (Saliva, as already observed, appears to take a positive part in the digestion of farinaceous food, by assisting in its conversion into dextrine and sugar. If bread be incorporated with saliva, and the mass be allowed to stand for some time, it will be found to contain dextrine, or gum of starch, and sugar.—J. C.)
4. That the *agent* of chymification is the *gastric juice.*
5. That the pure gastric juice is fluid, *clear, and transparent;* without *odour;* a little salt; and perceptibly *acid.*
6. That it contains free *muriatic acid,* and some other active *chemical* principles. (The gastric juice certainly contains muriatic acid, but physiologists are not yet agreed whether it be as a free acid or in a state of combination. On the latter supposition, the muriatic acid which is obtained on distillation, is the result of decomposition by another acid.—J. C.)
7. That it is never found *free* in the gastric cavity; but is always excited to discharge itself by the introduction of *food* or other irritants.
8. That it is secreted from vessels distinct from the mucous follicles. (It is thought by modern physiologists to be secreted by glands specially provided for the purpose.—J. C.)
9. That it is seldom obtained pure, but is generally mixed with mucus, and sometimes with saliva. When pure it is capable of being kept for months, and perhaps for years.
10. That it *coagulates* albumen, and afterwards *dissolves* the *coagulæ.* (This has been disproved by Blondlot.—A. C.)
11. That it *checks* the progress of putrefaction.
12. That it acts as a *solvent* of food, and alters its properties.
13. That, like other chemical agents, it *commences* its action on food as soon as it comes in contact with it.
14. That it is capable of combining with a certain and fixed *quantity* of food, and when more aliment is presented for its action than it will dissolve, disturbance of the stomach, or "indigestion," will ensue.
15. That its action is facilitated by the *warmth* and *motions* of the stomach.
16. That it becomes intimately *mixed* and *blended* with the ingestæ in the stomach by the motions of that organ.
17. That it is *invariably* the *same substance,* modified only by *admixture* with other fluids.
18. That the motions of the stomach produce a constant *churning* of its contents, and *admixture* of food and gastric juice.
19. That these motions are in two directions, *transversely* and *longitudinally.*
20. That *no other* fluid produces the

* The inferences are given in Dr Beaumont's own words, and the italics also are his. Since his conclusions were drawn, the rapid advance of science has rendered many of them more than doubtful, and to these we have added some remarks within parentheses.

same effect on food that gastric juice does; and that it is the *only solvent of aliment.* (The correct statement is, that it is the only solvent of *animal* or *albuminous* aliment.—J. C.)

21. That the action of the stomach and its fluids is the same on *all kinds* of diet. (This is not the case.—J. C.)
22. That *solid* food, of a certain texture, is easier of digestion than *fluid.*
23. That *animal* and *farinaceous* aliments are more easy of digestion than *vegetable.*
24. That the susceptibility of digestion does not, however, depend altogether upon *natural* or *chemical* distinctions.
25. That digestion is facilitated by *minuteness of division* and *tenderness of fibre;* and retarded by opposite qualities.
26. That the *ultimate principles* of aliment are always the same, from whatever food they may be obtained. (This inference is evidently erroneous. The nutriment derived from fat or sugar is very different from that derived from flesh.—J. C.)
27. That *chyme* is *homogeneous,* but variable in its *colour* and *consistence.* (Late researches seem to prove that it is not homogeneous.—A. C.)
28. That, towards the *latter* stages of chymification, it becomes more *acid* and *stimulating,* and passes more rapidly from the stomach.
29. That the *inner coat* of the stomach is of a pale *pink* colour, varying in its hues according to its full or empty state.
30. That, in health, it is sheathed with mucus.
31. That the appearance of the interior of the stomach, *in disease,* is essentially different from that of its *healthy* state.
32. That stimulating *condiments* are injurious to the healthy stomach.
33. That the use of *ardent spirits always* produces diseases of the stomach if persevered in.
34. That *water, ardent spirits,* and most other *fluids,* are not affected by the gastric juice, but pass from the stomach soon after they have been received.
35. That the *quantity* of food generally taken is more than the wants of the system require; and that such excess, if persevered in, generally produces not only functional aberration, but disease of the coats of the stomach.
36. That *bulk* as well as *nutriment* is necessary to the articles of diet.
37. That *bile* is not ordinarily found *in the stomach,* and is *not* commonly *necessary* for the digestion of the food; but,
38. That when *oily* food has been used it assists its digestion.
39. That *oily* food is difficult of digestion, though it contains a large proportion of the nutrient principles. (As pointed out in Chapter III., pure fat is destitute of *albuminous* nutriment.—J. C.)
40. That the *digestibility* of aliment does not depend upon the *quantity* of nutrient principles that it contains.
41. That the natural temperature of the stomach is about 100° Fahrenheit.
42. That the temperature is not *elevated* by the ingestion of food.
43. That *exercise elevates* the temperature; and that *sleep* or *rest,* in a recumbent position, *depresses* it.
44. That *gentle exercise* facilitates the digestion of food.
45. That the time required for that purpose is various, depending upon the quantity and quality of the food, state of the stomach, &c.; but that the time ordinarily required for the disposal of a moderate meal of the fibrous parts of meat, with bread, &c., is from three to three and a-half hours.

Having concluded our survey of gastric digestion, we now proceed to trace the changes which the chyme undergoes in the small intestines. We have seen that in the stomach, animal and farinaceous food, and soft well-boiled ve-

getable substances, are reduced to an acid semifluid mass, from which the veins and absorbents abstract a considerable portion of the albuminous nutrient principles. That portion of the food which resists the action of the gastric juice, and that part of the chyme which requires to be submitted to the action of the bile and pancreatic juice in order to become fit for absorption, now pass into the duodenum, and are gradually mixed with these secretions. This is the commencement of intestinal digestion.

No subject in physiology has given rise to more abundant controversy than the nature of the action of the bile. The blood which circulates through the liver, passes twice through the capillary vessels; first through those of the intestines, and again through those of the liver itself; and as this organ is supplied with arterial blood by the hepatic arteries for its own nourishment, it is evident that the venous blood from the organs of digestion, bearing with it that portion of the nutritive parts of the food which is absorbed by the veins, is transmitted through the liver for the purpose of undergoing some peculiar change. Hence it is supposed that the liver, in addition to its recognised function of purifying the blood by separating from it the bile, has the office of modifying, in some manner, the nutritive particles, before they are mixed with the mass of the blood, and sent to circulate through the body. In its functions, therefore, the liver bears a strong analogy to the lungs. Black blood circulates through the parenchyma of both, and both excrete large quantities of carbon, the one in the shape of carbonic acid, and the other in the form of bile, which is a highly carbonaceous compound. Both, also, probably modify the nutritive products of the food;—the lungs, that portion which flows from the thoracic duct; and the liver, that portion which is absorbed by the veins. The carbonic acid from the lungs is a purely excrementitious product, and some physiologists regard the bile as equally such. But the experiments of Schwann, already mentioned (p. 40), prove that when it is conducted directly out of the system, without being allowed to enter the intestine, the animal immediately begins to droop, and speedily dies; whence it appears that the presence of bile is, at all events, necessary for the proper assimilation of the food. And there is no doubt that one of its chief uses is to promote the absorption of fat; for this substance resists altogether the action of the gastric juice, and passes unchanged into the duodenum: here it becomes intimately mixed with the bile, and forms an emulsion, from which the globules of fat are readily taken up by the lacteals, while they resist the absorbent power of the veins. It is true that, in experiments in which the gall-ducts were tied, fat still seemed to be absorbed by the lacteals; but the quantity was extremely small, and the chyle, instead of being white and creamy (which appearance it owes to the presence of the globules of fat), was almost transparent. When the bile mixes with the chyme, there results a precipitation of a considerable quantity of resinous matter (the resin of the bile), which passes off with the excrements; but it contains, besides, other principles (differently described by different chemists, according to the process of analysis pursued), which cannot afterwards be detected in the fæces. Hence, Liebig's hypothesis, that the bile furnishes, by its re-absorption, a considerable quantity of the carbon necessary for the maintenance of the animal heat, receives some degree of confirmation. If that hypothesis be true, the principles which disappear probably undergo decomposition before being absorbed; for chemical analysis has hitherto been unable to detect any of the constituent parts of bile in the contents of the lacteals. Müller thinks that the bile is a purely excrementitious fluid, but that it is of use in digestion by neutralising the acid of the chyme, and thus favouring the formation of chyle.* It is also useful in stimulating the peristaltic motions of the intestines, and hence a deficiency of bile is usually accompanied by constipation.

* Müller's Physiology, French edit., vol. i., p. 457.

Physiologists were long unable to ascribe any particular function to the pancreatic juice; but the rapid progress lately made in animal chemistry, has rendered it more than probable that this fluid exercises a powerful influence in the digestion of vegetable substances. It acts vigorously on starch, and changes it, in a very short time, into dextrine and sugar, and with far more energy than saliva. Our knowledge, however, of the use of the pancreas is still extremely limited; for the fact of carnivorous animals possessing the gland fully developed, is sufficient to make us pause before we ascribe undue importance to the chemical changes which its secretion may produce in vegetable aliment.* One of its principal uses probably is, to supply the chyme with the fluid which is necessary to admit of absorption (endosmosis) taking place. According to the late researches of M. Bernard, the pancreatic juice is requisite to enable the bile to form an emulsion with fat; for he observed, that when the pancreatic ducts were tied, no fatty matters found their way into the chyle.

A few general remarks may here be fitly introduced, on the way in which the food, after having undergone digestion, enters and becomes incorporated with the living system. Having, under the action of the various digestive organs, assumed a soluble form, it is absorbed, as we have seen, partly by the capillary veins, and partly by the lacteals; by the former, when it is capable of being at once transformed into blood, or is fit for serving immediately the purposes of respiration. A part, therefore, of the albuminous compounds appears to enter the blood-vessels directly, and to be added to the serum of the blood; while another portion, destined to form the globules and fibrine of the blood, is taken up by the lacteals. The pores of the walls of the capillaries, in the healthy state, are not large enough to allow the passage of the globules of the blood, even if such were formed during the process of digestion; but no examination with the most powerful microscope can detect globules at all like them in the chyme, while in the chyle it is easy to recognise globules, which assume a greater resemblance to those of the blood, the farther they advance along the thoracic duct. The globules of fat, being too large to penetrate the walls of the capillaries, are taken up by the lacteals, and, as we have said, it is to them that the creamy appearance of the chyle is owing. This is readily proved by injecting into the bowels of an animal any oily emulsion: on making an examination an hour afterwards, it is found that the absorbents proceeding from the bowel are charged with a creamy fluid, instead of the yellowish transparent lymph which they usually carry. The products of the digestion of the hydrates of carbon, probably pass into the blood indifferently either by the lacteals or capillaries. Sugar may readily be detected in the chyle, and may be recognised, though less easily, in the blood. The difficulty of finding it in the blood, is owing to the minuteness of the quantity in which it can exist there, as it is subjected in the capillaries to rapid decomposition into carbonic acid, which is thrown out by the lungs. In diabetes, however (a disease in which the sugar formed in digestion does not undergo the process of secondary assimilation, and is therefore not consumed in the lungs), the saccharine principle is readily recognised in the blood and secretions. It would be foreign to our present purpose to enter upon the chemical details of the transformations which the various hydrates of carbon undergo in the body, our object being merely to furnish the reader with a general idea of the manner in which they are made subservient to the wants of the system. And it ought to be borne in mind, that most of the views advanced in this paragraph are probabilities merely, to which it is hardly possible to give the weight of proof.

Before concluding this part of the subject, I ought perhaps to add, that while we have thus studied what may

* The late investigations of Magendie have shewn that many of the animal fluids have the power of converting starch into sugar, and that this property is by no means peculiar to the saliva and pancreatic juice, though the latter acts with much greater energy than any of the other fluids.

not improperly be called the chemistry of digestion, and examined the changes effected on different kinds of food by the action of the gastric juice both in and out of the stomach, our conceptions of the true nature of the changes which take place would still be incomplete if we were not to advert to the influence of vitality in completing the process of assimilation. Closely as artificial and natural digestion may resemble each other, and identical as their results are in appearance and even in chemical properties, still it must be taken into view, that, while artificial digestion begins and ends in purely chemical changes, true chymification seems to extend beyond this point, and to constitute the first step towards the endowment of inanimate matter with the properties of life. It is impossible, indeed, for us to explain what vitality is, or at what exact stage of preparation the nutritive particles of the food first come under the influence of the vital principle. But knowing as we do, that life modifies, and even for a time controls, the ordinary laws of chemical action, and that its essence has hitherto defied the scrutiny alike of the chemist and the physiologist, a sound analogy warrants us in inferring with Dr Prout, that the process of vitalization begins during chymification, and, consequently, that digestion is really something more than a mere solution of the food in gastric juice. It is no sufficient objection to this inference to say that the most careful analysis can detect no difference betwixt natural and artificial chyme. On the same ground, life might be denied to the muscular tissue, because the very same chemical elements go to constitute both dead and living muscle. Nay, we have seen that, in the case of the gastric juice itself, its special properties are so subtle that an elevation of a few degrees of temperature is sufficient to annihilate them, although the ablest chemist cannot detect any change whatever in its chemical constitution or other properties. But although it may thus be impossible for us ever to penetrate the whole mystery of nutrition, it is not only entirely within our power, but directly incumbent on us, to investigate the nature of the changes produced during digestion, and the conditions or laws under which these changes take place; because it is only by a due and intelligent regard to the indications which they afford us, that we can hope ever to arrive at sound principles for the regulation of our conduct in matters of diet and regimen.

CHAPTER VIII.

CONDITIONS REQUIRED FOR SECURING HEALTHY DIGESTION.

Quality of food not the only important circumstance with reference to its digestibility—Physiological conditions must be observed, in order to secure good digestion—These generally overlooked by writers on diet, as well as dyspeptic patients—A different course adopted by the author, and why—Necessity of conforming to the natural institutions of the Creator with a view to enjoying health—Quality of food ought to be duly, though not exclusively, attended to—Importance of the recent discoveries in organic chemistry—Improper quality of food is the least usual cause of indigestion—Statement of the most frequent causes—When, however, indigestion exists, a proper selection of food is one of the most efficacious means of cure—Necessity of paying regard to all circumstances affecting the stomach through its sympathy with the rest of the body.

From the preceding exposition of the structure and functions of the organs concerned in chymification, it will be evident to the reflecting reader, that although the kind or quality of the food materially increases or diminishes the facility with which it is acted upon by the gastric juice, this is by no means the only circumstance affecting the result, but, contrary to the popular opinion, the strictest adherence to any prescribed form of diet will prove of comparatively little service in warding off indigestion, especially in persons predisposed to its attacks, unless the other equally influential circumstances by which digestion is promoted or retarded be also carefully attended to. So completely is this proposition borne out by experience, that examples are to be met with every day, where the same food which is digested with ease when the other physiological laws are attended to, remains for hours in the

stomach undigested when they are infringed or neglected. If, for example, we infringe one of these laws, expounded in Chapter XI., by sitting down to our usual meal in a state of exhaustion from severe exercise or mental agitation, indigestion will almost certainly ensue, however simple and digestible the food may be of which we have partaken; because, in such circumstances, the requisite secretion of gastric juice cannot go on in a healthy manner. For the very same reason, a similar result will follow if we eat too largely, too hurriedly, or too frequently; or if, immediately after a meal, we engage in deep thought or laborious exertion. In like manner, if we eat freely while spending our days in a close vitiated air, which renders the blood unfit for the due support of the various organs, indigestion will almost certainly follow, proportioned both in extent and severity to the degree and continuance of the aberration which occasions it; and will prove wholly intractable under any mere change of diet, unless the necessary changes in the mode of life be made at the same time, and duly persevered in. All of these causes are infringements of the conditions appointed by the Creator for the due performance of the digestive functions, and which cannot be disregarded with impunity. Hence, even after we have ascertained what kind of food is most suitable for the individual, we must still pursue our inquiry, and never rest satisfied till we have both ascertained and fulfilled the other and equally important conditions of healthy digestion.

So far, however, from this great principle being generally recognised and acted upon in practice, the proper quality of the food has hitherto been almost universally regarded as the chief, if not the only requisite, for the enjoyment of healthy digestion. Hence, while medical men are constantly questioned, whether this or that article of diet is good or bad for the stomach, curiosity rarely, if ever, extends so far as to inquire, whether Nature has annexed to sound digestion any other conditions, which also it may be expedient to know and to observe. The natural consequence has been, that, while numerous works have appeared, descriptive of the natural history and properties of alimentary substances, none, so far as I am aware, has systematically directed attention to the importance of a better acquaintance with, and more habitual observance of, those other circumstances by which digestion is so powerfully influenced. This remark applies almost as much to our latest and best treatises on Diet, as to those of older standing; for although Pereira, Truman, Bryant, and others, do not wholly overlook the physiological conditions, they have not insisted so earnestly on the importance of these, as they would have done had they been fully aware of the extent to which they control the progress of digestion, even when the quality of the food itself is unexceptionable. This omission is the more to be regretted, because the physiological conditions of digestion exert such an extensive influence over the assimilative and nutritive processes, that the subject of Dietetics cannot be fully understood or appreciated, without carefully studying their mode of action, and directing attention to their practical consequences. And I feel assured that, ere long, no treatise on Diet will be considered complete which does not assign them that prominent place to which their relative importance so clearly entitles them.

Influenced by these considerations, and by the fact, that, in many excellent works already existing, the constitution and properties of all the alimentary substances in common use are examined and described in ample detail, I have not hesitated to forsake the beaten path, and to dedicate these pages chiefly to the elucidation of the more neglected, but, practically, not less important department of the inquiry; and with this view, I have, in the preceding chapters, entered more into detail regarding the nature and laws of digestion, than I should otherwise have thought advisable in a work intended for the unprofessional reader. This course farther seemed to be necessary, because I could not otherwise

hope to carry along with me the conviction of the reader, that, in so far as the practical rules or principles deduced from these laws are correct interpretations of nature, they are, in reality, expressions of the will and design of the beneficent Creator, who instituted them for our advantage, and has given us a direct interest in discovering and conforming to them. Wherever, indeed, I have unintentionally mistaken or misrepresented the natural law, the inferences deduced from it must, of course, be equally erroneous and unworthy of regard. But in every instance in which I have drawn correct practical rules from accurately observed phenomena, I am entitled to insist upon their habitual fulfilment as a duty as clearly commanded by the Creator, as if written with his own finger on tablets of brass. Fallible man may obey or neglect the will of the Being who made him, and reap enjoyment or suffering as the consequence; but as he can neither create himself anew after a different model, nor alter the laws of that constitution which God has seen to be best adapted for him, his true happiness must necessarily lie in discarding the blind guidance of his own imagination, and following, in preference, the dictates of a wisdom which never errs. Till this truth be universally felt—till we come to live, move, and act under the habitual consciousness that the laws which regulate our bodily wellbeing are direct emanations of Divine omniscience and power, and not the mere offspring of human fancy—it will be impossible for us to escape the numerous evils inseparable from ignorance and its attendant rashness and presumption, or to secure for ourselves the many advantages and sources of enjoyment which a kind Providence has placed within our reach.

But while thus insisting on the necessity of paying increased regard to the dictates of the organic laws in all our dietetic arrangements, I am not less desirous that we should avail ourselves, to the utmost possible extent, of the benefits to be derived from a careful study of the nature and properties of the different kinds of food, and especially of the relation existing between their constituent elements and those of the living organism which they are intended to support and repair. The late discoveries in organic chemistry seem to me to have introduced us to one of the richest fields of research ever opened up to the physiological philanthropist, and to have afforded us, for the first time, fixed principles for scientific investigations, which, under the guidance of such men as Liebig, Dumas, and Mulder, have already led to highly important conclusions, and cannot fail shortly to bring still more valuable additions to our knowledge. This, however, is a subject on which it would be inconvenient to enlarge at present; but in Chapter XII. we shall introduce such an exposition of it as is consistent with the plan of this work.

The expediency of now directing attention chiefly to the influence of the physiological conditions, appears also from the fact, that, even when indigestion can be traced to the use of unsuitable food, some other marked infringement of the laws of digestion will almost always be found to have contributed to the result. For, provided the food be wholesome in quality, it is very unusual indeed, for a person previously healthy to experience more than a few hours' discomfort from accidentally partaking of unsuitable dishes. And accordingly, for one instance in which confirmed dyspepsia arises merely from the improper preference of one article of food to another, *without any other infringement of the physiological laws*, ninety-nine will, I venture to say, be met with, in which the error may be traced to long-continued neglect of some one or more of the organic laws on which I so strongly insist. If this be true, it follows that, for one case in which a better selected diet, without regard to the other conditions, will *alone* effect a cure, ninety-nine will occur in which the remedy will fail. Here, of course, I speak only of indigestion as it occurs in a person otherwise healthy; for nothing is more certain than that, when

other disease of a serious kind is present, injudiciously-selected food will often do irreparable injury. This consideration, however, falls exclusively within the province of the physician, and the subject cannot be properly discussed in a work intended to teach, not the art of curing disease, but the means of preserving health.

In society, accordingly, we meet with innumerable instances of persons of every age and variety of constitution, who, simply by paying reasonable attention to the quantity eaten, and to the times and circumstances of their meals, partake of every kind of food, and yet continue to enjoy a sound digestion. We know, moreover, as a palpable fact, that the majority are not, in the slightest degree, influenced in the choice of their food by any consideration of its suitableness to their constitutions, but entirely by the habits of the circle or country in which they live, and the kind of food within their reach; and, to a considerable extent, this must ever be the case. It is only by invalids, or during disease, that any pains are usually taken to suit the diet to the existing state. Health once restored, the individual generally resumes his former habits, and awaits the return of disease before he again thinks of restricting himself in the choice of his food.

But while I admit the apparent impunity with which indiscriminate eating, within proper limits as to quantity, &c., is often indulged in, my object is by no means to recommend it as proper in itself, but only to demonstrate the great influence which the physiological conditions, also, exercise on digestion, by shewing that, *when they are fulfilled*, even the frequent use of unsuitable food may fail to produce dyspeptic disease in persons not predisposed to it. For it cannot be doubted that great advantage would result from a systematic and judicious adaptation of diet to individual conditions and temperaments. Every one can tell from his own experience that some kinds of food are more digestible, and contribute more to his nutrition, than others; and, judging from analogy, we may infer from the extraordinary modifications of the body produced in horses and cattle by changes in the mode of feeding, how much we ourselves might be benefited by similar means.

In now soliciting the reader's attention, therefore, to the influence of the more neglected conditions of healthy digestion and nutrition, my great desire is *to increase the advantages to be derived from a well-selected diet*, by shewing how much the digestibility and nutritive power of the food are affected by conditions, which, although in general easily observed, are yet, from ignorance, too often wholly overlooked.

If I am correct in this view of the relative importance of the physiological laws of digestion, the inference to be drawn from it is clear enough. For persons in health and leading a regular active life, the selection of the kind of food to be used, provided it be wholesome, and contain a sufficiency of nourishment, is of decidedly less consequence than the due observance of the laws or conditions under which its digestion is carried on. If a person in the enjoyment of good health be content to eat only at proper intervals of time, and in quantity proportioned to the previous exercise and real wants of the system (or, in other words, in proportion to the quantity of gastric juice which the stomach can furnish for its digestion), and at the same time pay reasonable regard to due mastication, &c., he may very safely be permitted to eat of fish, flesh, fowl, or any other kind of food, according to his own inclination and the opportunities of choice afforded him. Whenever the state of the system at the time shall require one kind of food in preference to all others, inclination will generally prompt him to choose it, if within his reach. Again, where no such grounds of preference exist, a natural love of variety will prompt to an occasional and beneficial change. That, in such circumstances, digestion is unimpaired, we may learn by observing around us multitudes of persons who, although by no means scrupulous in

the selection of their food, nevertheless remain, during their years of active exertion, free from all stomachic disorders, chiefly from paying a reasonable degree of attention to the other organic laws; and it is from the observation of this very fact, that many practical physicians have expressed the opinion, that it matters much less than is often imagined what even a dyspeptic eats, provided he proportion the *quantity* to the impaired tone of the stomach, and pay due regard to exercise, purity of air, cheerful occupation, and the other general laws of health. Without going quite so far as this, it will be admitted by all experienced men, that, provided moderation be attended to, many cases of indigestion may be cured without any considerable restriction as to the kind of food to be used. At the same time, it is quite certain that their cure would be facilitated by the aid of a judicious choice of food, in addition to moderation.

On investigating the causes of indigestion, then, we rarely meet with cases in which it has arisen *exclusively* from an injudicious preference of one article of diet to another. In by far the greater number of instances, it is produced by the other causes already referred to, the tendency of which is to impair the tone, not only of the stomach, but of the whole system. As a natural consequence of such an origin of indigestion, no modification of diet which can be devised will succeed in effecting a cure, unless the exciting cause be also removed by a suitable change in the mode of life. The active symptoms may be mitigated by medicine, and temporary relief be obtained by an alteration of diet; but the evil will continue to recur so long as the impediments to healthy digestion, arising from the habitual infringement of the organic laws, are suffered to remain.

When, however, either dyspepsia or any other form of serious disease is once fairly established, the proper regulation of diet is often one of the most efficacious means of cure; and an accurate acquaintance, on the part of the physician, with the properties of food, then becomes indispensable to successful treatment. Accordingly, it is to the physician, rather than to the general reader, that the existing treatises on Diet are calculated to be of much service; for he alone can turn their information to account. To the public at large, who usually eat of whatever is set before them, and rarely know beforehand what dishes are to appear on their tables, it is of comparatively little moment to study the qualities of every individual article of food, and its relation to peculiarities of individual constitution. It is far more important for them to possess such a knowledge of the nature and laws of digestion, as shall be equally applicable to the regulation of their conduct whatever the nature of their meals may be.

It ought never to be forgotten, that the stomach is not an isolated organ which can thrive or suffer without affecting, or being affected by, the state of the other organs. On the contrary, it is most closely connected by sympathy with the whole bodily frame; and disease can scarcely shew itself in any part, without the digestive organs speedily participating in the derangement; nor can the stomach itself become diseased, without greater or less disturbance of the general system. For these reasons, in seeking to secure the blessings of healthy digestion, we must not only give a preference to easily digestible over indigestible food, but also have constant regard to those circumstances which influence the stomach through its sympathy with the rest of the organism. We must vary our regimen (using that word in its true and comprehensive sense, and not as embracing diet alone) according to age, constitution, and mode of life; and we must so regulate our meals with respect to time, quantity, and other conditions, as at once to facilitate digestion, and promote the health of the system at large. To enjoy permanently a sound state of the digestive functions, the health of the muscular system, for example, must be secured by adequate but not excessive or ill-timed exercise; because, if this be neglected,

little waste of tissues will occur, little appetite for food be felt, little gastric juice be secreted, and, consequently, little power of digestion be enjoyed. If, on the other hand, *too much* exercise be taken, muscular and nervous exhaustion will ensue, and extend equally to the stomach itself; and hence the frequency of indigestion after a full meal, taken in a state of exhaustion. For a similar reason, the health of the lungs must be promoted by full and free respiration in a pure and temperate atmosphere; because, without the fulfilment of this condition, healthy and well-constituted blood cannot be formed, and because the functions of the stomach, in common with those of other organs, become impaired when it is deprived of a sufficiency of nourishing blood. The due action of the skin, too, must be secured by proper attention to bathing, cleanliness, and clothing; because otherwise the excretion of waste materials cannot go on efficiently, and their retention in the system will affect both the blood and the general constitution, and thereby also impair the digestive powers. In like manner, the health of the brain and nervous system must be secured by active and cheerful occupation of the intellect and feelings, otherwise the tone of the stomach will become impaired, and its powers be proportionally reduced. All of these requisites are essential to the preservation of vigorous and healthy digestion, because the Creator has so linked together all the important organs, that none of them can fail in its duty without injuring the rest, and being injuriously acted upon by them in their turn.

If I have been guilty of too much repetition in this chapter, I beg that the fault may be ascribed to my anxiety to fix as firmly as possible, in the mind of every reader, a principle of great practical importance, and which has hitherto been too generally overlooked.

In accordance with the views above explained, I shall, in the next chapter, proceed to consider the times at which our meals should be taken—a point of no small importance in the regulation of diet.

CHAPTER IX.

TIMES OF EATING.

Meals should be regulated according to the wants of the system—Times of eating—No stated hours for eating—Five or six hours of interval between meals generally sufficient—But must vary according to circumstances—Habit has much influence—Proper time for breakfast depends on constitution, health, and mode of life—Interval required between breakfast and dinner—Best time for dinner—Circumstances in which lunch is proper—Late dinners considered—their propriety dependent on mode of life—Tea and coffee as a third meal—useful in certain circumstances—Supper considered—General rule as to meals—Nature admits of variety—Illustrations—but requires the observance of principle in our rules.

If it be kept in mind that, as fully explained in the chapter on Appetite, the objects of eating are simply to afford materials for growth, and to supply the expenditure incurred in carrying on the operations of life, it will be obvious that Nature intended us to regulate our meals by the actual wants of the system, and not to eat at stated hours as a matter of course, whether nourishment be required or not. On this principle, two moderate meals a-day may prove quite sufficient for a person leading a sedentary and monotonous life, while double the number, and double the quantity of food, might not be even enough for a young man growing rapidly, and at the same time much engaged in active and athletic exercises. The proper rule, accordingly, is, that whenever we are engaged in laborious occupations which induce a rapid expenditure of material, or when growth is going on so fast as to require unusually ample supplies, food should be taken both more frequently and in larger quantity than when the mode of life is sedentary and unvaried, and growth is no longer going on. In other words, *food ought always to bear a relation to the age, mode of life, and circumstances of the individual.*

But while the above is unquestionably the correct principle on which all our practical rules ought to be based, it may be remarked, that the animal economy is constituted with so strong a tendency to periodical activity, that, after growth is completed, and the waste

of the system has become, from uniformity in the mode of life, in some measure definite and regular, as great an approximation as possible ought to be made to fixed times of eating. In general, little difficulty and much advantage attend the arrangement; because, where the business and habits of society are nearly the same throughout a whole class, equal waste will go on, and, consequently, the demand for a supply of nourishment in all the individuals composing it will be felt at nearly the same intervals, subject only to such variations as are produced by differences of age and constitution. As regards each class, therefore, regularity in the recurrence of meals is not less natural than advantageous; and it is only when we attempt to combine a given order of diet with different and even incompatible modes of life, that Nature refuses to sanction the arrangement.

So strong, indeed, is the tendency to periodicity in the system, that appetite returns for a time at the accustomed hour, even after the mode of life, and consequently the wants of the system, have undergone a total change.

Nature has accorded to man considerable latitude in fixing the interval within which the demands of appetite must be gratified, and in this provision has obviously had in view the infinite variety of circumstances in which he may be placed in the discharge of his numerous duties. As a general rule, five or six hours should, in mature age, elapse between one meal and another —longer if the mode of life be indolent, and shorter if very active. Gastric digestion occupies from three to five hours, according to the nature and abundance of the meal, and the state of health; but it would be injurious to begin another meal the moment this process is completed. Like other organs which have been in active exercise, *the stomach requires an interval of rest after the process is finished, to enable it to recover its tone, before it can again enter upon the vigorous performance of its function.* Appetite, accordingly, does not begin to be felt till some time after the stomach has become empty; and if food be taken before it has enjoyed sufficient repose, the secretion of gastric juice and the contraction of its muscular fibres will be alike imperfect, and digestion will consequently become impaired. If, again, food be taken before the digestion of the preceding meal be completed, the result will be still worse; because the whole of the gastric juice which the stomach can secrete, being already engaged in the solution of the first meal, the one subsequently taken will necessarily remain unsupplied, and consequently be liable to undergo the same chemical change—fermentation —which would occur in it if exposed *out of the stomach* to an equal degree of heat and moisture. Dr Kitchiner, in speaking of the advantage of giving the stomach an occasional rest, truly and forcibly remarks, that "unless the constitution is so confoundedly debilitated that the circulation will not run alone, abstinence is the easiest, cheapest, and best cure for the disorders which arise from indigestion or intemperance." In these cases, indeed, abstinence is to the exhausted stomach what repose is to the wearied muscles, and hence the benefits which result from its judicious observance.

The interval between each meal ought to be longer or shorter in proportion to the quantity eaten, and to the age and more or less active habits of the individual; and it would be absurd to fix the same standard for all. A growing young person requires frequent supplies of nourishing food to furnish the materials of growth, in addition to those of waste, which also is more active in early life than after maturity. For a similar reason, a strong labouring man, whose system is subjected to great waste from being engaged all day in hard work, will require not only more frequent but more copious meals than an indolent and sedentary man; and those who eat very little will require to eat at shorter intervals than those whose meals are heavy. An invalid on restricted diet may thus require to eat every four hours, where, with a more copious diet,

once in six hours would be sufficient. Some persons are so constituted as to require only one or two abundant meals in twenty-four hours.

Early training exercises great power over the stomach as well as over the mind. In savage life, where the supplies of food are precarious, a single meal may be copious enough to serve for two or three days together. The monks of La Trappe make it part of their religion to eat only once a-day, and nothing but vegetable food—unless when sick, in which case milk is allowed; but it is long before they become reconciled to the restriction. Some years ago, I travelled for three days in a French diligence with one of the order, then on his way from Italy to the monastery of La Trappe, near Nantes, and observed that he scrupulously adhered to his single meal. He had a dispensation, however, authorising him to eat animal food and use wine during his journey; and I was surprised at the extent to which he availed himself of the permission, by devouring at one time a store that seemed sufficient to last for a week instead of a day. But, as in the case of the boa constrictor in similar circumstances, a deep lethargy immediately succeeded, and it was not till four or five hours afterwards that his almost apoplectic features became again animated and expressive: long before next meal, however, his renewed appetite betrayed itself by expressive glances towards the comforts of the breakfast-table.

Nature, then, *has fixed no particular hours for eating*, but has established principles easy of discovery and of application, by which, and by attention to the dictates of appetite, all may readily adapt their diet to their respective ages, constitutions, and habits. According to these principles, whenever the mode of life is uniform, and the expenditure of the system pretty equable, fixed hours for meals may be safely adopted; but where those are irregular, the intervals between meals ought also to vary, and the safest guide will then be the recurrence of true appetite—a sure sign that the system is in need of a supply, and that the stomach is now ready to secrete the gastric juice necessary for its digestion.

It is evident, then, that the times of eating ought to be regulated by the habits of the individual. If, adhering to the order of nature, we work by day and sleep by night, an early breakfast, an early dinner, and an early evening meal, will undoubtedly be the most conducive to sound digestion and the enjoyment of health. But if, against the laws of nature, we pass the morning in bed, reserve our activity till late in the afternoon, and do not go to sleep till two or three hours before daybreak, then assuredly the late breakfasts and dinners, now so fashionable, will be the best for our comfort that can be devised. Here the grand error is, not so much in breakfasting at noon and dining at eight o'clock, as in the unnatural mode of life which renders earlier hours impossible. For, so long as such a mode of life is persisted in, we should only add to its injurious effects by attempting to combine it with the observance of the early hours of eating, suited to those who live in conformity with nature. It is impossible, then, to name any hour as that at which breakfast ought always to be taken. Mankind present such differences of age, health, occupation, and constitution, that it would be folly to attempt to devise one system of diet which should be equally applicable to both young and old, to the active and the indolent, the sound and the sick. The true aim of science ought to be the discovery of the principles according to which the requisite modifications should be made in each individual case. Accordingly, taking the laws of the animal constitution for our guide, we may safely recommend those who eat supper not to breakfast till one or two hours at least after rising; while those who dine late and eat nothing afterwards, and whose digestion is vigorous, may with propriety breakfast earlier. Individuals of a delicate frame are often unable for either bodily or mental exertion in the morning, and are invariably injured by any attempt at active exercise or serious thinking before breakfast; but

strong healthy persons, and invalids in whom digestion is slow rather than diseased, may enjoy, and even be benefited by, two or three hours of activity before their morning meal, especially if accustomed to eat supper. If the physiological principle be kept in view, a little experience will enable any one to decide what time is the most suitable for himself. As a general rule, perhaps, about half an hour or an hour after rising will be found the most suitable time; but those who rise very early will do well to follow the French custom of taking a cup of coffee or tea, and bread, on getting up, and to reserve their appetite for a more substantial breakfast three hours later. This is an invaluable rule for students, who often seriously impair their digestive functions by studying for hours in the morning, regardless of the craving of the system for nourishment and support.

If exposure of any kind is to be incurred in the morning, whether to the weather or to causes of disease, it becomes a matter of much importance that breakfast or some substitute for it should be taken previously. It is well known that, from the great activity of the absorbents caused by want of nourishment, the system is more susceptible of infection, and is less capable of resisting the deleterious influences of cold, miasma, and other morbific causes, in the morning before eating, than at any other time; and hence it has become a point of duty with all naval and military commanders, especially in bad climates, always to give their men breakfast before exposing them to morning dews or other noxious influences. This practice is so efficacious, that, in a case mentioned by Sir George Ballingall, of a regiment quartered in Newcastle, among whom typhus fever was very prevalent, an early breakfast of warm coffee proved the most effectual means of checking the progress of the disease. In aguish countries, also, it is uniformly found that the proportion of sick among those who are exposed to the open air before getting any thing to eat, is much greater than among those who have been fortified by a comfortable breakfast. Where there is any delicacy of constitution, the risk is of course increased.

That this greater susceptibility in the morning than at any other time really arises from the craving activity of the absorbents, excited by the wants of the system, and the length of time which has elapsed since the preceding meal, is proved both by facts and reasoning. If we suppose the previous meal to have been taken at six o'clock in the evening, not only nutrition, but the various secretions and exhalations, must have been carried on for the fourteen or fifteen hours between that time and the usual hour for breakfast, without any fresh supply of nourishment; and consequently every part of the system must be sensible of a want, and craving to have it supplied. The result is, that in a healthy state of the constitution, there is felt in the morning a keen and agreeable, because not overpowering appetite, which gives a zest to the plainest food, and renders breakfast eminently a comfortable and invigorating meal. And if, in these circumstances, food be taken, the absorbents, refreshed by repose and stimulated by want, act vigorously, and imbibe the chyle as fast as it is formed. But if food be denied to them, the same proneness to energetic action will impel the *pulmonary* and *cutaneous* absorbents to imbibe any morbific or other matter which may be presented to them. When, on the other hand, the system is fully replenished by timely supplies of nourishment, the absorbents become inactive, and, consequently, any noxious effluvia that may be present in the air, are less likely to be imbibed than under opposite circumstances.*

The function of absorption, then, is at its highest pitch of activity in the morning, and immediately before dinner, simply because every part of the

* The custom of taking the most fluid and least substantial meal in the morning, is in strict accordance with nature; for the great loss of fluid by exhalation during the night causes a natural demand for liquids in the morning, while the loss of solids consequent on active exertion during the day creates a proportionate demand for a more substantial repast in the afternoon.

frame is then craving for a supply to repair the losses which it has sustained; and if, in this state of fasting, the body be exposed to miasma or other atmospheric impurities, it will be much more liable to suffer from the absorption, by the skin and lungs, of these deleterious matters, than after a meal, when the absorbents have been supplied with their proper food. This is the true theory of the greater susceptibility of infection and other poisonous influences when the stomach is empty.

So rapid is absorption from the stomach in the morning, that I have repeatedly seen from five to six pints of a saline mineral water taken at eight o'clock, and a very hearty breakfast finished within half an hour after the water was drunk! When in bad health a few years ago, I observed almost equal expedition in my own person. I took half a pint of ass's milk at seven o'clock, and in consequence of coughing violently was seized with vomiting and retching within twenty minutes after taking it; but only twice or thrice was any portion of the milk perceptible, although the stomach was entirely emptied. This was even more remarkable than the other case, inasmuch as milk undergoes digestion, which water does not. In allusion to this rapidity of absorption, Sir Francis Head, when speaking of the quantity of the chalybeate waters swallowed of a morning at the Brunnen of Nassau, humorously remarks, that "one would think that this deluge of cold water would leave little room for tea and sugar; but miraculous as it may sound, *by the time I got to my 'Hof' there was as much stowage in the vessel as when she sailed;* besides this, the steel created an appetite which was very difficult to govern."*

In setting out to travel early in the morning, a light breakfast before starting is a great protection against colds and subsequent fatigue or exhaustion. I am quite aware that robust and healthy men can and do take much active exercise before breakfast with apparent impunity if not benefit, and I have often done so myself; but experience ultimately taught me that I sooner became exhausted on continuing the exertion through the day, than when I *began* by eating a little. During the first winter of my studies in Paris, I regularly accompanied the surgical visits at the Hotel Dieu, which began at six o'clock in the morning, and lasted till nine or frequently half-past nine. Not being then aware of the principle under discussion, I ate nothing till my return home; but before the day was done I felt more weariness than the mere exertion ought to have produced. At last, on noticing for a time the regularity with which many of the work-people passing along paid their respects at a small shop, the only one then open, where fancy rolls were sold, along with wine and brandy, I thought of following their example to the extent of trying how far a roll would add to my comfort. I soon found great reason to be pleased with the expedient; and discovered that I was not only less exhausted during the day, but more able to follow the lecture which concluded the visit, and in possession of a keener appetite for breakfast at my return: and ever since, I have acted on the principle now inculcated, and with marked benefit. I was then astonished at the regularity with which the Parisian workmen seemed to take their morning allowance of brandy on their way to their labours, apparently for the very purpose of getting that wholesome energy which they ought to have sought in food alone.

During the prevalence of cholera both here and on the Continent, it was often remarked that a large proportion of the attacks occurred early in the morning, in persons who had gone to bed apparently well. Chronic invalids and persons of a delicate habit of body are also familiar with the fact, that animal heat and vigour diminish towards morning. When reduced in strength by pulmonary complaints, I often passed the night in comparative comfort, sure to awake about four or five o'clock with a feeling of chill and absence of animal heat, which I could

* Bubbles from the Brunnens of Nassau.

not dissipate till after receiving sustenance.

From these facts, the general inference is clearly warranted, that delicate persons ought to have some kind of food soon after rising, and that even those who are robust will act wisely in not exposing themselves unnecessarily to fatigue, infection, or other morbid causes, without having previously supplied the wants of the system, either partially by a cup of coffee, tea, or milk, or entirely by a regular breakfast. Where fever, for example, is in a family, the danger of infection will be much greater to a person going directly from his own bed to the bed-side of the patient, than to one who first takes the precaution of drinking were it only a cup of coffee. I have elsewhere noticed the safety which Captain Murray obtained for his crew in the West Indies, partly by attention to this rule; and have likewise referred to the experience of Sir George Ballingall in the prevention of fever by a similar expedient.

In the last edition of this work it was observed, that, in the army, there seemed to be much room for improvement in the arrangements of the soldiers' meals. According to the regulations then in force, the dragoons, for example, breakfasted at eight o'clock, and dined at one. But as, in summer, they rose at four o'clock, and in winter at five, and were kept busy in the stables till eight o'clock, the more improvident among them must, by that time, have been nineteen hours without food. They had no allowance of any kind after one o'clock, till the following morning. The more prudent amongst them, it is true, clubbed together for tea or other evening refreshment, procured at their own expense. But as many of them were too inconsiderate to reserve any portion of their small pay for this purpose, they had no resource but to sustain the pains of hunger as they best could till the following morning. This would have been a smaller evil, if their duties required little muscular exertion, or the climate were warm. But when we consider that most of the men are at a time of life when the waste of the system is great, and that their duties are both severe and long-continued, it is obvious that no small suffering must have resulted from such lengthened abstinence. The very exhaustion thus produced in the improvident men, could not fail to add great force to the craving for the stimulus of spirits, which so few of them are able to resist, and which cannot be successfully kept in check without ample and regular supplies of food. A great improvement, it is gratifying to add, has lately been introduced, by issuing an order which renders an afternoon meal of coffee and bread compulsory, as far as this can be effected by deducting the expense (about a penny farthing daily) from the pay of each soldier. The coffee is usually served about six o'clock. We are informed also, that the dragoons now rise in summer between five and six o'clock, and in winter between six and seven.

For similar reasons, whenever the young (who require abundant sustenance) are made to rise early, as in many families and boarding-schools, an early breakfast is almost an indispensable condition of health. On the Continent, in such establishments, seven o'clock is the common hour for breakfast, especially in summer.

In recommending what I conceive ought to be the general rule, let me not be understood as wishing to extend it so far as to advise those whose matured or peculiar constitutions admit of two or three hours' activity before breakfast, to abandon what experience proves to be beneficial to them. My only wish is to help those who are in doubt as to choosing the plan which is most likely to be of advantage, and to relieve those who are already suffering from ignorance.

The morning meal being comparatively a light one, and the stomach being then in high vigour, digestion goes on briskly, so that appetite revives within a shorter time than after the more substantial dinner. Accordingly, in all nations and classes of society not perverted from the course

of nature, a longer interval than five hours rarely elapses between breakfast and dinner. Our forefathers dined at noon, as our sailors continue to do at the present day. Over no small portion of the Continent of Europe, the same primitive hour is still adhered to; and among the labouring population of Great Britain, one or two o'clock is the common dinner-hour, eight or nine being that of breakfast. Even the rich manufacturers of Manchester, and other English towns, continue to this day to dine at one o'clock; and the very universality of a mid-day meal among those who rise early, is itself a strong presumption in favour of its propriety, and of its being in harmony with the laws of the animal economy.

To prevent business from interfering unduly with digestion, it was formerly the custom in large towns to shut up shops and counting-houses for two hours in the middle of the day; and in Switzerland I have seen the same practice followed. The members of the family being then assembled, relaxation and enjoyment take the place of the cares of the world; and the result is highly satisfactory. The appetite is keen enough to induce them to eat with zest all that nature requires, while it wants the resistless force which is given by a fast of eight or nine hours. There is, consequently, slower mastication, less cramming, and a much earlier return of the aptitude for business; while, at the same time, the mental and bodily faculties are refreshed by the interruption of their accustomed labour, and the affections cherished by healthful domestic intercourse taking place before too much weariness is induced to permit of its being enjoyed. In England, such weariness is a very common occurrence. The parent and husband, exhausted by the eager pursuit of wealth during the livelong day, returns home in the evening jaded and harassed, and little able to take pleasure or interest in the enjoyments of his wife and family. Hence, indeed, too often arise indifference and estrangement between those whom Nature has formed as if on purpose to increase each other's happiness.

In enterprising commercial communities—in London and Liverpool, for example—it is a common practice to hasten away to the counting-room immediately after an early breakfast; to remain there in active employment from nine or ten o'clock in the morning till six o'clock in the evening; and then to hurry home to a late dinner at six or seven o'clock, by which time the vital functions have become so far exhausted as to create a strong desire for indulgence in something stimulating both in food and drink. If this desire be gratified, immediate relief will be obtained, and a temporary feeling of comfort pervade the frame; but nothing can be more erroneous than to regard this as a proof of the indulgence being beneficial. The organism soon gets accustomed to the stimulus; its susceptibility becomes impaired by the frequency with which the excitement is administered; and, in a short time, indigestion is the inevitable consequence.

The evils attendant on this course of life are frequently aggravated by the preposterous means resorted to for their prevention. Having some vague notion that *exercise* improves digestion, and not being at all aware that there is an improper as well as a proper time for taking it, many persons, after being exhausted by seven or eight hours' confinement to the counting-house, proceed to take a walk of four or five miles before going home to dinner, and thus utterly throw away the little strength that was left to them, and are filled with disappointment on finding their appetite and digestion worse than before.* Dr Paris mentions the case of a clerk in a public office, who brought upon himself all the horrors of dyspepsia and melancholy by following this plan. He breakfasted at nine, went to his office at ten, continued there till five, walked till seven, and then dined. He was cured in six weeks, by adopting a

* Respecting the proper regulation of exercise, see The Principles of Physiology applied to Health and Education, chapter vi.

more rational regimen, and dining at three o'clock.

Many females and delicate persons injure their powers of digestion by delaying their exercise till the system is too much exhausted to profit by it. In boarding-schools, from the desire which is felt to have all the lessons over before allowing any play, the same error is often committed, and with pernicious effects on the health of the pupils.

In the United States of America, again, an evil of a different kind is prevalent. Dinner is not delayed, as with us, till a late hour in the evening; but it is snatched and eaten with a precipitate haste, equally hostile to moral enjoyment and to sound digestion. Amidst hurry and bustle, and while the mind is still labouring under all the anxiety and excitement of business, the food is swallowed in larger quantity than is required, and very imperfectly masticated. The natural consequences are, that indigestion prevails to an extent unknown elsewhere; and that the thin and hungry leanness of the people has become almost as proverbial as the portly paunch, and ruddy, well-fed cheeks, of their great ancestor John Bull, from whom, in this respect, they have so much degenerated. The error, however, seems to be the result more of the exciting circumstances amidst which the Americans live, than of any merely constitutional peculiarity; for similar transgressions, attended by similar effects, are only too common on our own side of the Atlantic, whenever the spirit of competition runs high.

As a general rule, then, not more than five hours ought to intervene betwixt breakfast and dinner. If the mode of life be such as involves great activity in the open air, or if the period of life be one of rapid growth or filling up (as during youth, or convalescence from illness), the interval ought to be shortened; whereas, if the mode of life be sedentary, and unattended with much activity of nutrition, the interval may be considerably protracted with but little inconvenience. Much, also, ought to depend on the natural rapidity or slowness of digestion. In some constitutions, chymification goes on so slowly, that the individual can pass with ease eight or ten hours without food; whereas, in others, it is so rapid, that a fresh supply becomes necessary in half the time. Spallanzani himself was an example of the former kind; for in him digestion went on so slowly, that he was unable for study till five or six hours after even a very spare dinner. The proper rule in every case is, *to take dinner at such an interval after breakfast as the return of healthy appetite indicates*, whether that interval be longer or shorter than the average specified. This rule is the best which can be followed, because the return of appetite is the only indication on which we can rely, of the stomach being now in a condition to secrete the necessary quantity of gastric juice for the digestion of the meal. If we eat before this indication occurs, a portion, at least, of the food will remain undigested, from deficiency of the secretion, and the stomach itself will become exhausted and debilitated by being thus prematurely forced to exertion. If, on the other hand, we delay too long after the return of appetite, not only the stomach itself, but all the bodily organs, will suffer from the want of nourishment: and if the practice be persevered in, disease will spring up in that organ which is naturally the weakest; or the system at large will become debilitated, and prone to suffer from causes which, under a better regimen, would have been easily withstood.

That, according to the arrangements of Nature, the time for dinner should *generally* be somewhere about five hours after an ordinary breakfast, is evident from the almost universal return of appetite at the end of such an interval, and from the fact that many, through sheer inability to resist longer the wholesome cravings of nature, are in the regular practice of eating dinner at that time, but to save appearances give it the name of *luncheon;* by which means they hold themselves entitled to the enjoyment of a second and more substantial dinner later in the day.

Invalids, dyspeptics, and all who, possessing vigorous digestion, wish to retain it, will do well to follow the intentions of Nature, and observe the intervals which she has appointed. Those who disregard them, and still digest without difficulty, have reason to be grateful to Providence; but they may rest assured that they will longer enjoy their privilege, and better evince their gratitude, by regulating their conduct according to the ordinary laws of the animal economy, than by presuming too much on their supposed exemption from the bad consequences of habitual infringement.

Supposing nine o'clock to be the hour of breakfast, the natural dinner-hour would thus be two o'clock; and such, accordingly, is that sanctioned by the most extended experience, and which ought to be adhered to by all who wish to enjoy the highest health of which they are susceptible, and the nature and regularity of whose occupations will admit of its observance.

Artificially arranged, however, as society now is, whole classes of the community, from business and other causes, find it impossible to dine till much later in the day. The question then comes to be—As we cannot implicitly follow the system laid down by Nature, what is the nearest approximation which we can make to it? Ought we to eat nothing till we can find time to dine, at five, six, or seven o'clock; or ought we rather to take a light luncheon at the natural time, about one or two o'clock, and delay eating a more substantial meal till the later hour at which alone we can find leisure to digest it?

From the exposition already given, the reader will have no difficulty in determining that the latter plan is most in accordance with the organic laws. If we leave the stomach too long empty, its powers, as well as those of the system at large, become impaired from exhaustion; and therefore, when dinner cannot be taken earlier than seven or eight hours after breakfast, most people will find it advantageous to partake of some slight refreshment in the mean time—enough to blunt the keenness of appetite, but not entirely to destroy it. When a person is exposed to much bodily exertion in the open air, or is at the period of rapid growth, a portion of animal food, or an ordinary luncheon, taken in moderation, may be allowable, and even requisite; but where the habits are sedentary and the constitution formed, a bit of bread or biscuit, and a glass of water, will be far more serviceable. But it is with idle people as with children. Leave them without occupation, and their chief amusement will then be derived from the indulgence of their appetites. Hence the prevalent pastime of forenoon-visits to the pastry-cook's, where the appetite is indulged with as little regard to the real wants of the system, or the condition of the stomach, as if digestion were meant merely as an appendage to taste. Many young persons do themselves serious injury in this way, and then complain loudly of the discomfort which attends the subsequent indigestion of a heavy dinner. To relieve the weakness, arising not from exhaustion, but from the oppression of satiety, they resort to wine, as if by adding fuel to the fire they could reasonably hope to extinguish the flame!

Even in fashionable life the superiority of Nature's arrangements over those of man is so far acknowledged, that it is an almost universal rule for children to dine early in the day; and there cannot be a doubt that the practice is attended with manifold advantages to the young, although, as regards their moral training, these would be greatly increased were they to associate at meals with their parents, instead of being left entirely to the company and management of servants.

Here I cannot refrain from earnestly soliciting the attention of the reflecting parent to the injury inflicted by the irrational mode of life and education to which the young are generally subjected. As growth and nutrition are in their highest activity in youth, it follows that at no period of life is strict adherence to the organic laws of so much moment as then; because,

if the system does not receive at the proper intervals the supplies of food of which it stands urgently in need, it must necessarily become impaired in tone, and more liable to the inroads of disease. The completed and compact frame of an adult may resist for a time delay or irregularity in its supplies; but the undeveloped and susceptible organism of the young suffers from the very first, and the evil increases in proportion as the aberration from the order of nature is repeated. Hence reason, affection, and enlightened benevolence, all concur in enforcing a strict adherence to an early dinner-hour for the young. On no account whatever ought it to be delayed beyond one or two o'clock. And yet if we examine the customs of society, especially in the middle and higher ranks resident in towns, we find the school-occupations so irrationally arranged, that while the children are obliged to breakfast early, even in winter, to reach school in time, most of them find it impossible to dine till five or six o'clock—*eight* or *nine* hours after their first meal, instead of *four* or *five*. And when stunted growth, feeble digestion, delicacy, or bad health results as the natural consequence of exhaustion, instead of ascribing it to its true cause—the deprivation of sustenance—and trying to cure it by a better regulation of the diet, it is usual to leave the evil to do its worst, and to content ourselves with complacently lamenting the degeneracy of the age, and boasting of the marvellous constitutions and hardihood of the children of *our* younger day, whom neither wind nor weather could hurt. If it were a favourite colt or dog whose training we were superintending, the folly of shutting it up all day in a confined atmosphere, and denying it exercise and food at proper intervals, would be at once perceived.

The evil, however, is the source of much suffering and disappointment; and, as it cannot be corrected until the public is rendered fully aware of its existence and influence, it cannot be too often brought under notice, or too strongly condemned. The teacher alone has not the power of providing a remedy. The concurrence and co-operation of the parent are indispensable; but both combined could easily effect such a distribution of the time and business of the school, as to leave at least two hours in the middle of the day appropriated to dinner and play after it in the open air. It is no valid objection to say that in winter the day is too short to allow the "sacrifice" of so much time. The shorter it is, the greater is the necessity for making the most of it by adequate attention to the laws of health. The real "sacrifice" of time is when health is impaired and progress retarded by undue confinement, and deprivation of exercise in the open air. The very shortness of the day, indeed, implies that we should employ the hours of darkness in *indoor* occupations, and make the most of the daylight by going out while we have it; and I have no doubt that, as society advances, this truth will be felt and acted upon to the great advantage and delight of the young.

An additional, and, with right-thinking people, an irresistible reason for reforming this error in education is, that, while it injures the physical system, and in delicate constitutions seriously affects the health, it is scarcely less hurtful to the mind, for which the sacrifice is made. Experience has shewn, that the excessive cultivation of the intellectual faculties in the young, to the disregard of the laws of the physical organization, is productive of evil even to the intellect. When schooling and tasks are continued daily for many successive hours, the attention flags, and the vigour of the mind becomes impaired instead of being increased. In this way the progress made is in the end much smaller, and acquired at a much greater risk of health and life, than when suitable intervals are allowed, not only for eating meals at the times required by the wants of the system, but also for the enjoyment of adequate muscular exercise in the open air. In some schools where a more rational system has been tried—where the confinement to school has been lessened by one-

half, and the time for meals and exercise has been doubled, as well as arranged on sound physiological principles—the results have been, not only improved health and increased physical activity, but also more rapid intellectual progress, and a more perfect development of mental vigour. In the one case the mind is exhausted by the continued and monotonous strain upon the attention, while the body suffers from want of exercise, food, and pure air. In the other, the mind is strengthened by strong calls which rouse and agreeably engage attention, and the body also gains vigour from receiving nourishment at the right time, and obtaining that muscular exercise in the open air without which health cannot long be preserved.*

Supposing it to be made an imperative condition of our social existence that we shall rise after mid-day, and not go to bed till a late hour in the morning, the present fashion of dining at seven or eight o'clock becomes much more rational than is commonly imagined by those who declaim against it without regard to the concomitant circumstances. It is, no doubt, a very bad plan for a man who rises at seven or eight o'clock, breakfasts at nine, and goes to bed at eleven, to delay dining till seven in the evening; but it by no means follows that seven is a bad dinner-hour for a person who rises at twelve or one o'clock, breakfasts at two, and goes to bed at three in the morning. The interval between the breakfast at one and dinner at seven o'clock, is the same as between breakfast at nine and dinner at three, namely six hours—which is little more than enough. As already observed, the error lies, not in the hours chosen for meals, but in the utter perversion of the whole system of living, by which night is converted into day, and the business of life is postponed five or six hours beyond the time appointed by the Creator for its performance. So far from the late dinner being hurtful in such circumstances, it would be perfectly proper if the mode of life which leads to it were itself imperative. Under the present perverted system, accordingly, it is only the stimulus and support which the late dinner affords, that enable the victims to withstand the fatigue even for a single week.

No one has a stronger conviction, than the writer of these pages, of the injury done to society by the wide departure from the laws of nature, by which its present arrangements are characterised; and no one is more anxious to contribute all he can to reform them: but in returning to the order of nature, the whole mode of life must be amended and brought into harmony with the laws of the animal economy; and no real progress will be made by merely altering the hour of dinner, while the conditions which have led to the existing arrangement are left unchanged.

In the country, even among the higher classes, a greater approximation to the order of nature is observable than in towns. The inducements to sleep away the day, and to be awake during the night, are diminished; bodily exercise and exposure to the open air are more indulged in; the appetite becomes keener, and digestion more vigorous; and, in consequence, meals are taken an hour or two earlier. But throughout all these changes, the general feature of having some kind of refreshment, either luncheon or dinner, within four, five, or six hours after breakfast, may be pretty accurately traced.

If two hours of relaxation from business can be obtained about five or six hours after breakfast, the best plan, unquestionably, is to dine then. But if this be impossible, and active exertion of mind or body must be continued for several hours longer, it will be far better to eat some light refreshment in the forenoon, and to postpone dinner not only till business is over, but *till half an hour or an hour's repose has allowed its attendant excitement or fatigue to subside.* By this means the stomach will enter upon

* The reader will find this subject more fully discussed in the last edition of The Principles of Physiology, &c., Chap. xii., "On the Conditions of Health of the Brain."

its duties with vigour, and the dinner be digested with greater comfort and despatch than if we sit down to table the moment our work is finished. It hence appears that the tedious quarter of an hour preceding the announcement of "*dinner*" is far from being lost to the subsequent digestion; and dyspeptic invalids, who, from pure ignorance of the mischief they thereby entail upon themselves, are in the habit of engaging in study, business, or exercise, till the last moment before beginning to eat, would be surprised at the increased comfort to be derived from allowing themselves an interval of cheerful relaxation preparatory to every meal.

In like manner, very few people, immediately after eating a good dinner, can return, with continued impunity, to bodily or intellectual labour. On this account, actors, for example, whose vocation requires exertion of both mind and body, generally either dine very early, or take their chief meal at night when they return home, the latter being the most common practice. Students, literary men, and persons intently engaged in business, are very apt to injure themselves by neglecting relaxation at and after meals; and I could point even to medical men of eminence who have carried their disregard of the Creator's laws so far, as systematically to have continued their studies during meals, till broken health forced them to desist; and who, in this repect, aggravated the evil by the injurious influence their example was likely to exercise over their young and ardent followers, who naturally looked up to them as guides.

The time for dinner ought, then, to vary according to the constitution, occupations, and mode of life of the individual; and the nearer the whole of these can be made to approximate to the intentions of Nature, the more vigorous will be the power of digestion, and the more complete the nutrition of the body; and consequently, the more easily will the stomach recover the tone which it may have lost from previous mismanagement. Accordingly, when attempting to cure indigestion, it ought never to be forgotten for a moment, that the most scrupulous adherence to the rules given for the proper selection of food, will prove of very little avail, if we continue at the same time to neglect the ordinary laws of health: whereas, if we act in accordance with the conditions which God has appointed for the performance of healthy digestion, by early rising, regular exercise of the various functions of mind and body in a free and pure atmosphere, eating moderately, and enjoying social relaxation after our meals, digestion will be so far strengthened, even in delicate constitutions, that no very rigid adherence to any particular kind of diet will be necessary; it being always understood, however, that we shall not exceed in quantity what the wants of the system require.

It would be a waste of time to discuss gravely whether *tea or coffee* ought to be allowed in the evening. Custom has already decided the point, and experience has shewn that, in moderation, they rather promote than impede digestion. But when taken strong and in large quantity, especially by persons of a sanguine or nervous constitution and weak digestion, they are decidedly hurtful. Many ruin their health and induce severe nervous depression by the abuse of strong green tea, at the very time when they profess not to know any cause to which their misery can be ascribed. Literary men, artists, actors, and other public performers, who are subjected at times to great intellectual or moral excitement, also very frequently suffer from the abuse of tea or coffee. When the dinner is early—say at one, two, or three o'clock—a light meal of tea and bread in the evening is very suitable, as it saves the necessity of eating a heavier supper. If the individual be accustomed to much active exertion in the afternoon, so as to cause considerable waste in the system, and especially if he be young, a small addition of animal food may with great propriety be made to the evening meal. But, on the other hand, when the dinner is late, or little exer-

tion is incurred after it, tea or coffee ought to be used more as a diluent than as a meal.

The French drink a single cup of strong coffee without cream immediately after dinner, and find digestion go on all the better for it. It acts as a strong stimulant, and certainly increases the feeling of comfort for the time. Like all other stimulants, however, its use is attended with the disadvantage of diminishing the sensibility of the part on which it acts, and inducing weakness. This inconvenience is not felt to the same extent, indeed, after coffee as after spirits, but still it exists; and as it is infinitely better that the stomach should be brought up to do its own work willingly, than trained to depend upon assistance from without, such assistance ought to be reserved for the relief of occasional exhaustion, instead of being resorted to as a regular indulgence. The French partake of a much greater variety of dishes at one meal than we are accustomed to do, and may thus require the aid of coffee to keep the stomach from actual rebellion. But the proper way to obviate this necessity, is obviously to eat a more simple and moderate meal.

In determining the admissibility of a third meal, either as tea or as supper, the general principle already laid down ought to be our guide. If no luncheon be taken, and dinner be sufficiently early to admit of digestion being completed, and of the stomach being afterwards recruited by repose, and if the mode of life be active, so as to occasion a natural return of appetite before the day is done, the propriety of a third meal cannot be questioned. But if dinner be late, and there be too short an interval between it and bedtime to admit of digestion being finished and the appetite renewed, then every additional mouthful swallowed is sure to do mischief, especially if, from eating luncheon, dinner is in reality a third meal. For example, the farmer who dines at two o'clock, and, after walking about his fields for three or four hours in the afternoon, comes home in the evening with a genuine and undeniable appetite, has a legitimate right to an additional supply of wholesome food before going to bed; because a sufficient interval has elapsed to allow the stomach to recover from the labour of digesting his dinner, and because the system, from the continued waste occasioned by exercise, stands in need of repair. In like manner, the man of fashion who dines at seven o'clock, and frequents assemblies till three or four in the morning, is well entitled to some kind of supper about one or two o'clock, and could scarcely endure the fatigue attending his pleasures, without this farther sustenance from either food or wine, or both. Even in his case, six hours may thus intervene betwixt dinner and supper; and we know that, on an average, the digestion of a moderate meal is finished in four or five hours. The chief difference between him and the farmer is, that the farmer secures health and sound digestion by adhering in his hours to the institutions of the Creator, while the man of fashion impairs his constitution and enfeebles his digestion—less by the improper intervals at which he eats, than by his wide departure from the order of nature in the perverse mode of life which he adopts.

If, influenced by the example of Cornaro, and following the precepts of ultra-temperance, we eat sparingly, dine early, live actively, and go to bed with the stomach entirely empty, we *may* sleep, but our dreams will scarcely be more pleasant, or our sleep more tranquil, than if the stomach were overloaded. In such circumstances, a gnawing sense of vacuity is felt, which is apt to induce restlessness, nervous impatience, and irritability. I have repeatedly seen these unpleasant symptoms dispelled, and sound sleep obtained, by no other prescription than a cupful of arrow-root an hour or two before bed-time.

Where tea is made to constitute a meal, supper is altogether superfluous, except in early life, and in the case of those who lead a very laborious existence, and observe very early hours. In youth, waste, growth, and nutrition

are so active, that a moderate supper is often indispensable, especially when the muscular system is freely exercised in the open air. But it ought to be of a light nature, and taken at least an hour before going to bed. If dinner be taken early, and tea be used in the afternoon, not as a meal but merely as a diluent, a light supper will be very proper.

In short, the grand rule in fixing the number and periods of our meals, is *to proportion them to the real wants of the system as modified by age, sex, health, and manner of life, and as indicated by the true returns of appetite;* and, as an approximative guide, to bear in mind that, under ordinary circumstances of activity and health, from three to five hours are required for the digestion of a full meal, and one or two hours more of repose before the stomach becomes thoroughly fit for the resumption of its labours. If the meal be temperate and the mode of life natural, digestion will be completed in from three to four hours, and one hour of rest will serve to restore its tone; but if the quantity of food be great, or the general habits indolent, digestion may be protracted to five or six hours, and two or more be required for subsequent repose. It is therefore utterly absurd and inconsistent with the laws of Nature, to pretend, as many writers have done, to lay down rules which shall apply to every individual and to every variety of circumstances. As already mentioned, rules applicable to *classes* may be prescribed, because there is a considerable similarity in the circumstances of the individuals comprehended in each; but even there, numerous temporary or accidental exceptions must occur, which require appropriate modifications of the general rule. The Creator, indeed, obviously does not intend that we should be bound down to the rigid observance of unimportant details in diet. All that He requires of us is, that when the ever-varying circumstances in which we are placed compel us to deviate from the abstract standard of right, we shall still adhere as far as possible to the principles assigned for our guidance. If we do so in essentials, great deviations from our ordinary mode of living may be made at the call of duty or necessity with little or no disturbance of health. Indeed, it is astonishing how rapidly a healthy frame accommodates itself even to great changes, when conducted with ordinary prudence.

In suiting my own mode of life to the circumstances under which I have at various times been placed, I have repeatedly, even as an invalid, made sudden changes in the hours of eating, with no further injury than temporary discomfort; but then I always adhered to the general principles above insisted on. It was by some of these experiments that my attention was first drawn to the great influence of the accessary conditions in retarding or promoting digestion. At one time, on altering my place of residence from Aix to Marseilles, I changed at once from breakfasting at eight o'clock, dining at two, and taking tea in the evening, to breakfasting at eleven and dining at six. For the first few days I felt uncomfortable from waiting so long in the morning; but by following the plan of taking a cup of coffee and a crust of bread soon after rising, and not attempting any considerable bodily exertion till after breakfast, every feeling of inconvenience ceased, and the system completely adapted itself to the change. Three months afterwards, I embarked on the Mediterranean, and again passed at once to breakfasting between seven and eight o'clock, dining about noon, and taking tea in the evening; which I continued to do for some time after arriving in Italy. On my way home the hours of eating were never two days the same, and yet I did not suffer. If breakfast was early, I ate it with relish. If it was late, I had recourse to a biscuit or some dried fruit early in the morning, to sustain the system in the mean time, and was ready for it when it came. In the same way, if dinner was to-day at one o'clock, I took it when it was offered, and had recourse to some refreshment in the evening; if next day it was postponed till eight o'clock, which sometimes happened, the refreshment

came in the forenoon, and a moderate meal was taken in the evening.

In these changes, however, it will be remarked that the laws of digestion were in reality much less infringed as to time than one might imagine from merely hearing that I dined one day at noon and the next day at eight o'clock in the evening. At whatever hour the meal was taken, the real wants of the system were supplied when they manifested themselves in the form of appetite, and the requisite intervals were observed. If a substantial breakfast was taken at eight o'clock, then a corresponding interval elapsed before another meal followed at one or two. If, again, the morning allowance was trifling, then the real breakfast followed at an interval correspondingly short, namely, at eleven o'clock. So also with dinner. And if dinner was at one o'clock, tea followed at the distance of six or seven hours; whereas, if dinner came at six or seven o'clock, a refreshment preceded and nothing followed it, and the results were comfort and sound digestion. If, however, we yield unguardedly to the impulse of appetite in travelling, and eat and drink plentifully instead of temperately, no arrangement of hours that we can make will render our situation either pleasant or healthful.

While, therefore, it seems to be obvious beyond a doubt, that those who live according to the laws of Nature and begin their activity with the morning, should breakfast betimes, dine early in the day, and take a lighter meal in the evening,—the reward of which conduct will be health and vigour of mind and body, unattainable to the same extent by those who live differently, and convert night into day,—it would be not less hurtful than absurd to prescribe the same hours for meals to all, whatever their periods of activity, and whatever their modes of life; and I cannot help thinking, that it is the preposterous attempt to generalise too much, while losing sight of true principle and the modifications which it requires in individual cases, that has brought dietetic precepts into disrepute, and led to the belief that the rules laid down are merely arbitrary assumptions, resting on no solid foundation in the human constitution, or in the designs of our Creator.

As experience is the best guide to knowledge, I may be allowed to add, that, when travelling on the Continent in health and strength, I suffered more from feverish fatigue and stomachic discomfort, induced by ignorant infringement of the laws of digestion, than I ever afterwards did, even from more continued exertion, when travelling as an invalid under a better regulated system of diet. I did not, in either case, make any exception to the meals which awaited our arrival at the inns, or to the hours at which they were served. The chief difference was, that, when well, I ate till my appetite was fully satisfied, under the notion that, in travelling, a full diet is necessary to enable one to withstand the fatigue; while, as an invalid, on the other hand, I ate more sparingly, and, if the regular meal was much later than usual, had recourse to biscuit, fruit, or a slice of cold meat, as an intermediate refreshment, to prevent the stomach becoming exhausted from too long a fast. Following the dictates of experience, I have long adhered to the latter plan, and am convinced that few who have tried both will long prefer the former.

CHAPTER X.

ON THE PROPER QUANTITY OF FOOD.

Quantity to be proportioned to the wants of the system—Appetite indicates these—Cautions in trusting to appetite—Guiding principle to its indications—Circumstances which cause a necessity for food—Food required to generate animal heat—to repair organic waste—and supply materials for growth—Influence of each of these on appetite—Appetite keenest during growth and after much activity; and feeble in sedentary persons—Its dictates, however, must be correctly interpreted—General error of eating too much—Exercise increases the need of food, and best promotes digestion—Deficient diet of the labouring classes—Failing of appetite in fever, &c.—Over-eating in Germany, America, and Britain—Indigestion oftener arises from excess than from quality of food—No standard quantity can be fixed—Mixtures of food hurtful chiefly as tempting to excess—Examples of disease from excess, in servant-girls from the country, dressmakers, &c.—Great care needed at puberty—Mischief from excessive feeding in infancy—and among adults—Purgatives not naturally required—Diseases

from over-eating—Indigestion often prevents greater evils—Under-feeding and great mortality of the poor—Fatal effects of under-feeding in the Navy—Both mind and body injured by deficiency of food—Children of all ranks often suffer from this cause.

THE next important step in the regulation of diet, is to determine the QUANTITY which ought to be eaten.

To ensure easy digestion and sound health, the quantity of food ought always, in accordance with the physiological principle already explained, to be proportioned to the extent of the bodily waste. This is the only standard which admits of universal application during health; and if, disregarding the temptations of taste and luxury, we were always willing to listen to the plain and unbiassed indications of appetite,—the only natural index to the wants of the system,—and to yield implicit obedience to its dictates, we should very rarely err in eating either too much or too frequently. But as amidst the complicated arrangements of an advancing civilisation, circumstances are constantly occurring to pervert or obscure the indications of nature, it becomes doubly important for us to investigate the physiological conditions on which appetite depends; that we may, as far as possible, obtain the aid of reason in addition to that of instinct, in interpreting its intimations, and in determining the quantity, as well as the times, of our meals.

Nourishment being necessary chiefly for the purposes of repairing waste and affording materials for growth, it is, of course, always required in greatest quantity when these processes are going on most actively; and both occur in perhaps their highest intensity in growing young men much engaged in active exercise in the open air. In perfect harmony with this fact, it is well known that in no other circumstances is appetite so keen, digestion so vigorous and rapid, and the demands for food so frequent and irresistible. On the other hand, when these conditions are present in the lowest degree, as in females of a mature age and indolent temperament, living much within doors, appetite is in general easily satisfied, and digestion so feeble as to become a frequent source of discomfort. It is true that many persons who are by no means remarkable for activity, eat more largely than others who are subjected to much greater muscular exertion. But in doing so they act in opposition to the obvious dictates of nature, and generally sooner or later entail upon themselves a state of impaired health, which it is often difficult to remedy without an entire change in their habits. Unintentional errors of this kind, indeed, sometimes occur from confounding the suggestions of taste with those of appetite—a mistake which may, in general, be easily guarded against by those who possess a moderate amount of physiological knowledge. But as the whole value of appetite, as a dietetic guide, depends on its intimations being correctly interpreted, it will be useful if the reader, before pursuing the subject farther, will again peruse the explanation given in the second chapter, of its true nature and indications.

The leading principle to be kept in view then is, that the Creator has established a direct relation between organic waste and the desire for food; in virtue of which, in a state of health, appetite becomes more or less keen in proportion as waste goes on more or less rapidly. But to enable the reader more easily to understand this connexion, I shall now add to what has been already said in the first and third chapters, a few remarks on the channels through which that waste takes place, and on the purposes to which food is applied in repairing it.

Liebig has not unaptly likened the living animal body to fuel in a state of slow combustion. It is, in truth, "a heated mass which bears the same relation to external objects as any other heated mass." When placed in a cold atmosphere, or surrounded by cold bodies, it rapidly gives out heat; and when placed in a highly-heated atmosphere, or in contact with hot bodies, it receives heat from them. In England, and most other parts of the world, the air is constantly much colder than the healthy human body; and, as a necessary consequence, heat is continually abstracted from it with

a rapidity proportioned to the coldness of the atmosphere and other surrounding objects.

When the human body is much cooled down below its natural standard, the vital organs cease to act, and life becomes extinct. When the abstraction of heat is more rapid than usual, but not sufficiently so to cause immediate death, the vital operations become impaired, and disease ensues; which, if no means be used to counteract the cooling process, also runs on sooner or later to a fatal termination.

Such being the relation of the human body to the external atmosphere, it follows necessarily that some provision must exist for the constant generation of heat in the animal economy to supply the place of that which is abstracted, and that the rapidity of its generation must bear a direct relation to the rapidity of its abstraction by the external cold.

The provision made for this purpose consists in the combustion, so to speak, of certain elements of the food in the animal economy, the result of which is the generation of precisely the same amount of heat as would have been produced had the same quantity of the same elements been burnt in the open air; and there is every reason to believe, that such combustion is the sole cause of the heat supplied for the support of animal life.

The process of ordinary combustion is well known to consist in the union of the burning body with the oxygen of the air, and the formation of a new compound. In the burning of a piece of wood, for example, the carbon which it contains unites with the oxygen of the air and forms carbonic acid. In the burning of common gas, again, the hydrogen of the gas combines with the oxygen of the air and constitutes water. In both instances, the quantity of heat generated holds a fixed and unalterable relation to the quantity of carbon or hydrogen consumed. If the combination of the two bodies be rapid or instantaneous, the whole heat will be produced rapidly or at once; whereas, if it be effected very slowly, so as to require many hours for its completion, the quantity of heat generated at any given moment will be very small, but at the end *its total amount will be precisely the same as if the whole had been produced by an instantaneous and scorching explosion.*

Keeping this explanation in view, the unscientific reader will cease to be startled at the statement, that the generation of animal heat depends entirely on the combustion of the carbon and hydrogen of the food within the body. The whole difference is, that, in the animal economy, a comparatively small quantity of materials is consumed by a process of *slow and indirect combustion;* while in a stove or other fire-place larger masses of materials are consumed with great rapidity, and by direct combination with oxygen.*

Here, then, is one of the great processes of waste which are continually going on in the animal economy, and which require to be duly provided for. Our food is the source from which the new materials are derived; and the oxygen with which its constituent carbon and hydrogen combine, is supplied to them in the lungs during respiration. Hence, in proportion to the extent and frequency of the respirations, and the quantity of oxygen taken in, is, *cæteris paribus*, the quantity of heat generated.

The relative proportions in which the carbon and oxygen, and the hydrogen and oxygen, combine during combustion, are fixed and invariable. When, therefore, oxygen is supplied to the body, a proportional supply of carbon and hydrogen is required to combine with it; and if this be not provided, the oxygen attacks and decomposes or consumes the organism itself. This is what happens in a healthy man when deprived of a sufficiency of food. The capacity of the lungs remains the same; but as the scanty diet does not afford a sufficiency of carbon and hydrogen to support the animal heat, the oxygen takes what it requires to make up the deficiency from the living body itself, which, conse-

* For an explanation of the chemistry of the process of slow combustion, see Liebig's Animal Chemistry, third ed., p. 32, *et seq.*

quently, undergoes decay, with a rapidity proportioned to the scantiness of the food, and the largeness of the supply of oxygen (which necessarily varies with the amount of exertion made), till death terminates the scene. In illustration of this, Liebig quotes a case from Dr Currie, in which an individual, deprived of food by inability to swallow, lost 100 lbs. in weight in the course of a single month. And a precisely similar result is observed in hybernating animals, which go to sleep, fat and sleek, in the beginning of winter, and awake in spring, lean and exhausted. During the whole of the intervening months their heat and vitality have been supported literally by the slow combustion of their bodies; and their hybernating temperature falls many degrees below that of their active or summer state, simply because the combustion, unsupported by fresh supplies of fuel (or food), is now too low to generate, in a given time, nearly the same quantity of heat which was produced in the opposite circumstances.

The tissues of the body are not all consumed with equal rapidity, or in equal degrees. The fat, which, in a given bulk, yields by far the greatest amount of combustible material, disappears most rapidly, and almost entirely. Chossat found that, on an average, a warm-blooded animal loses about two-fifths of its weight before it dies of hunger; and he calculated that, while the fat lost 0·933 of its total amount, the blood lost 0·750, the muscular system 0·423, the organs of respiration 0·222, the bones 0·167, and the brain and spinal cord only 0·019, of their original substance, which he estimated from the weight of the same organs in healthy animals that had been purposely killed.* A fat person, therefore, supports starvation much better than a lean one, as he carries in his body a large supply of fuel on which his system can fall back for support. The comparatively small loss which the nervous system suffers is very remarkable. Had the brain been as liable to absorption as the other tissues of the body, one day's abstinence would have been followed by fatuity.

In winter, the same weight of air occupies a smaller space than in summer, because it contracts under the influence of cold. As a necessary consequence, we inhale a larger quantity of air in breathing, and also require more food, in cold than in warm weather. This is a beautiful arrangement of Providence, being obviously designed to counteract the more rapid cooling of the body occasioned by the colder atmosphere. In accordance with this arrangement, the appetite invariably becomes keener, and the relish for food abounding in carbon and hydrogen becomes greater, as the intensity of the cold increases. Letellier found from actual experiment that the quantity of carbonic acid given off by the lungs stands in direct relation to the temperature of the surrounding atmosphere. Thus, when the quantity of carbonic acid given off in an hour by a guinea-pig, at a temperature of 15°–20° centigrade (59°–68° Fahr.) was 2·080 grammes,* it fell to 1·453 grammes at a temperature of 30°–40° centigrade (86°–104° Fahr.), and rose to 3·006 grammes, when the thermometer marked 0° centigrade (32° Fahr.) In a canary bird the proportion of carbonic acid exhaled at a high and a low temperature, was as 1 to 2·5; in a greenfinch, as 1 to 2·2; in a guinea-pig, as 1 to 2; and in two mice, as 1 to 2; thus clearly proving that the consumption of food or fuel increases with the cold.† Within the tropics, where there is little waste of animal heat, the appetite is weak, and watery fruits and vegetables are preferred. In temperate climates, where cooling goes on more rapidly, the more nourishing grains, and animal food, come into request; while, in the arctic regions, vegetable food is almost wholly discarded, and the fattest animal food and oils, abounding in carbon and hydrogen, are devoured with a relish, and in quantities, which astound the natives of more temperate

* Recherches Experimentales sur l'Inanition, p. 92. Paris, 1843.

* The gramme is equal to 15·433 grains Troy.

† Annales de Chimie et de Physique, tome xiii., p. 478.

climes. In the frozen wilds of North America, the Hudson's Bay Company allow their servants 8lb. of buffalo meat daily per man, and the fattest portions are always preferred. It must, however, be observed, that this weight includes bone, and that no farinaceous or other vegetable food is supplied. In the Hudson's Bay territory; *pemmican* is considered the least bulky article of nourishment that can be taken on a winter journey. It is prepared by drying buffalo meat in the sun, or over a fire, pounding it, and then mixing it with one-third of its weight of melted fat.* Perhaps no other compound could afford a more concentrated supply for the waste of the body, and of fuel for respiration.

It is in consequence of this dependence of animal heat upon the food as its primary source, that, as Liebig remarks, "the cooling of the body, by whatever cause it may be produced, increases the amount of food necessary. The mere exposure to the open air, in a carriage, or on the deck of a ship, by increasing radiation and vaporization, increases the loss of heat, and compels us to eat."† The same principle explains why cold wintry weather causes so much suffering and mortality among the poor, who, especially in times of manufacturing distress, cannot obtain a sufficiency of food to produce the requisite bodily heat, or of clothing to preserve that which is generated. "A fall," says the Registrar-General, "of the mean temperature of the air from 45° to 4° or 5° below the freezing point (32°) of water, destroys (in a week) from 300 to 500 lives in London. It produces the same results on a larger scale all over the country."‡ It is indeed melancholy to think how many thousands of the poor are, in the midst of the greatest national prosperity, annually cut off in this way, by diseases originating exclusively, if not in absolute want, at least in a deficient supply, of the common necessaries of life. In many workhouses and hospitals for the young, great injury has been done by reducing the diet to the lowest ebb, and not allowing sufficient clothing or fire to insure adequate bodily heat.

In Franklin's Journey to the Polar Seas, we find the following observations by Dr (now Sir John) Richardson, in reference to an occasion on which he was nearly drowned from becoming benumbed in attempting to cross a river at a low temperature, when he was extremely reduced by hard exercise and fasting: they bear directly upon the point under discussion. "It may be worthy of remark," he says, "that I should have had little hesitation in any former period of my life, at plunging into the water even below 31° Fahr.; but at this time I was reduced almost to skin and bone, and, like the rest of the party, suffered from degrees of cold that would have been disregarded in health and vigour. During the whole of our march we experienced that no quantity of clothing could keep us warm while we fasted; but on those occasions on which we were enabled to go to bed with full stomachs, we passed the night in a warm and comfortable manner."*

Animal heat being generated by the combination of the carbon and hydrogen of the food with the oxygen of the air received into the lungs, and the proportions in which they combine being always the same, it follows that a person with large and capacious lungs will inhale more oxygen, require more food, and consequently generate more heat, than one with a small chest and feeble respiration. This ought, accordingly, to be taken into account in determining the quantity of food to be eaten; and it would lead only to mischief were a thin, narrow-chested person to adopt the dietetic standard of one oppositely constituted, merely because the latter found it suitable to his particular frame.

The other important purpose for which food is indispensable, is to repair organic waste, and, in early life, to supply materials for growth. Hence it is evident, that if, to the influence

* Franklin's Journey to the Polar Seas, vol. i., p. 117.
† Liebig's Familiar Letters, p. 73.
‡ Eighth Annual Report, p. xxxvii.

* Vol. i., p. 421.

of a low external temperature, we at any time add that of great bodily exertion and rapid growth, the necessity for copious and frequent supplies of nourishing food will become doubly imperative; because, while both the lost heat and bodily substance must be replaced, additions must also be made to the existing organism.

In endeavouring to regulate the supplies of nourishment with due regard to the necessities of the system, our chief reliance must be placed on enlightened attention to the dictates of appetite, between which and organic waste, as we have already seen, a direct relation has been established by the Creator. In virtue of this relation, appetite is most urgent in its demands when growth is most rapid, and when the individual is subjected to severe muscular exertion, especially in the open air, and in cold weather. In such circumstances, the body often loses several pounds in weight in the course of a few hours; and if a corresponding craving for food were not experienced with sufficient intensity to compel attention to the wants of the system, permanent injury would speedily ensue. Accordingly, whenever, in consequence of great bodily activity, unusual organic waste occurs, the desire for food becomes proportionally keen and irresistible. Appetite, then, when honestly and intelligently consulted, is, generally speaking, a safe guide to quantity; but in following its dictates we must take care to understand them aright, and neither to eat so fast as to prevent it from giving timely intimation that we have had enough, nor to confound the mere gratification of *taste*, or the yearning of a vacant mind, with the natural craving of unsatisfied want. Dr Beaumont's remarks on this subject are so sound, that I cannot refrain from here subjoining a very pertinent extract from his work:—

"There is no subject of dietetic economy," says he, "about which people err so much, as that which relates to *quantity*. The medical profession, too, has been accessory to this error, in giving directions to dyspeptics to eat until a sense of satiety is felt. Now, this feeling, so essential to be rightly understood, never supervenes until the invalid has eaten too much, if he have an appetite, which seldom fails him. Those even who are not otherwise predisposed to the complaint, frequently induce a diseased state of the digestive organs by too free indulgence of the appetite. Of this fact, the medical profession are, generally, not sufficiently aware. Those who lead sedentary lives, and whose circumstances will permit of what is called free living, are peculiarly obnoxious to these complaints. By paying particular attention to their sensations during the ingestion of their meals, these complaints may be avoided. There appears to be a sense of perfect intelligence conveyed from the stomach to the encephalic centre, which, in health, invariably dictates what quantity of aliment (responding to the sense of hunger and its due satisfaction) is naturally required for the purposes of life; and which, if noticed and properly attended to, would prove the most salutary monitor of health, and effectual preventive of disease. It is not the sense of *satiety*, for this is beyond the point of *healthful* indulgence, and is Nature's earliest indication of an *abuse* and *overburden* of her powers to replenish the system. It occurs immediately previous to this, and may be known by the pleasurable sensation of *perfect satisfaction, ease, and quiescence of body and mind.* It is when the stomach says *enough*; and is distinguished from satiety by the difference of the sensations,—the former feeling *enough*,—the latter *too much*. The first is produced by the timely reception into the stomach of proper aliment, in exact proportion to the requirements of Nature, for the perfect digestion of which a definite quantity of gastric juice is furnished by the proper gastric apparatus. But to effect this most agreeable of all sensations and conditions—the real Elysian satisfaction of the *reasonable* epicure—timely attention must be paid to the preliminary processes, such as thorough mastication, and moderate or slow deglutition. These are indispensable to the

due and natural supply of the stomach at the stated periods of alimentation; for if food be swallowed too fast, and pass into the stomach imperfectly masticated, too much is received in a short time, and in too imperfect a state of preparation to be disposed of by the gastric juice.

"The quantity of gastric juice, either contained in its proper vessels, or in a state of preparation in the circulating fluids, is believed to be in exact proportion to the proper quantity of aliment required for the due supply of the system. If a more than ordinary quantity of food be taken, a part of it will remain undissolved in the stomach, and produce the usual unpleasant symptoms of indigestion. But if the ingestion of a large quantity be in proportion to the calls of Nature, which sometimes happens after an unusual abstinence, it is probable that more than the usual supply of gastric juice is furnished; in which case the apparent excess is in exact ratio to the requirements of the economy, and never fails to produce a sense of quiescent gratification and healthful enjoyment. A great deal depends on habit in this respect. Our Western Indians, who frequently undergo long abstinence from food, eat enormous quantities when they can procure it, with impunity." (P. 63.)

It is, accordingly, from the direct relation subsisting between organic waste and the desire for food, that *exercise*, the effect of which is always to increase waste, is proverbially the first thing we think of recommending to improve the appetite and the tone of the digestive organs, when these are observed to be impaired. And where positive disease does not exist, no other remedy is half so effectual.

It is highly important that we should be fully aware of the existence of this natural relation between waste and appetite, and between appetite and digestion; because, if it be real, appetite must, when properly consulted, be the safest guide we can follow in determining when and how much we ought to eat. It is true, that, in disease, and amidst the factitious calls and wants of civilised life, its suggestions are often perverted, and that hence we may err if we blindly follow every thing which assumes its semblance. The conclusion to be drawn from this, however, is, not that the sense of hunger will, if trusted to, generally mislead us, but only that we must learn to recognise its true dictates before we can implicitly trust to its guidance: because, if its dictates are found to be erroneous even when consulted with care and intelligence, it will constitute the only known instance where the Creator has failed in the attempt to fulfil His design. Such an assumption is repugnant alike to feeling and to reason, and will be seen to be, moreover, wholly gratuitous, if we reflect how easily the apparent discrepancies which sometimes present themselves between the wants of the system and the dictates of appetite, may be explained on the more solid ground of our own ignorance or misapprehension.

Among the many practical errors that arise from overlooking the relation which nutrition ought to bear to waste and growth, is one often committed by young men, who, from having experienced all the pleasures of a keen appetite and easy digestion when growing rapidly or leading an active life, induce severe and protracted indigestion, by continuing, from mere habit, to eat an equal quantity of food when growth is finished and the system no longer requires the same extensive supply, or when a complete change from active to sedentary habits has greatly diminished that waste which alone renders food necessary. This is, in fact, one of the chief sources of the troublesome dyspeptic complaints often met with among the youthful inhabitants of our larger cities and colleges, and ought not to be lost sight of in the physical education of the young.

The error, however, is unhappily not confined to the young, but extends generally to all whose pursuits are of a sedentary nature. There are many persons, especially in towns and among females, who, having their time

and employments entirely at their own disposal, carefully avoid every thing which requires an effort of mind or body, and pass their lives shut up in warm rooms, in a state of inaction entirely incompatible with the healthy performance of the various animal functions. Having no bodily exertion to excite waste, promote circulation, or stimulate nutrition, and being seldom exposed to the invigorating influence of a cold atmosphere, they experience little keenness of appetite, have weak powers of digestion, and require but a limited supply of food. If, while inactive and expending little, such persons could be contented to follow nature so far as not to provoke appetite by stimulants and cookery, but to eat and drink only in proportion to the wants of the system, they would fare comparatively well. But having no imperative occupation, and no enjoyment from active and useful exertion, they find their time hanging heavily on their hands, and are apt to have recourse to eating as the only avenue to pleasure still open to them; and, forgetful or ignorant of the relation between waste and nutrition, they endeavour to renew, in the present indulgence of appetite, the real enjoyment which its *legitimate* gratification afforded under different circumstances. Pursuing the pleasures of the table with the same ardour as before, they eat and drink freely and abundantly; and, instead of trying to acquire a healthy desire for food, and increased powers of digestion, by a life of active usefulness and exercise in the open air, they resort to tonics, spices, wine, and other stimulants, which certainly relieve for the moment, but eventually aggravate the mischief by obscuring its progress and extent. The natural result of this mode of proceeding is, that the stomach becomes oppressed by excess of exertion—healthy appetite gives place to morbid craving—sickness, headach, and bilious attacks become frequent—the bowels are habitually disordered, the feet cold, and the circulation irregular—and a state of bodily weakness and mental irritability is induced, which constitutes a heavy penalty for the previous indulgence. So far, however, is the true cause of all these phenomena from being perceived even then, that a cure is sought, not in a better regulated diet and regimen, but from bitters to strengthen the stomach, laxatives to carry off the redundant materials from the system, wine to overcome the sense of sinking, and heavy lunches to satisfy the morbid craving which they only silence for a little. Some, of course, suffer in a greater and others in a less degree, according to peculiarities of constitution, mode of life, and extent of indulgence; but daily experience will testify, that, in its main features, the foregoing description is not overcharged, and that victims to such dietetic errors are to be met with in every class of society.

Some interesting observations which Valentin made upon himself practically illustrate these remarks, by shewing the very great influence of exercise over the amount of the exhalations from the skin and lungs. This distinguished physiologist having ascertained that the mean of his hourly insensible exhalations, during a period of three days, amounted to 51·6 grammes (about 1⅞ oz.),* found that he lost only 30 grammes when hungry and occupied in writing before dinner, and that the loss rose to 90·5 grammes when he got up and took active exercise. During the period of digestion after dinner, and in a state of repose, the loss amounted to 55·4 grammes; and in the evening, with active exercise in the sunshine, to 89·3 grammes, although he was very hungry: after supper, it rose to 132·7 grammes, with running exercise. A mere saunter did not increase the exhalations; for he found that, while his loss was at the rate of 37·8 grammes per hour during two hours and forty-five minutes spent in writing, including ten minutes employed in pacing backwards and forwards in his study, it amounted, during the subsequent hour, when he sauntered slowly about, to 34·4 grammes.†

* It will be remembered that the gramme is equal to 15·433 grains. An ounce contains about 31 grammes.
† Lehrbuch der Physiologie, vol. i., p. 728.

The fact that Nature means the inactive and indolent to eat and drink less than the busy and laborious, is established not only by the diminished appetite and impaired digestion of human beings who lead a sedentary life, as contrasted with the keen relish and rapid digestion usually attendant on active exercise in the open air, but on a yet broader scale by the analogy of all other animals. In noticing this relation, Dr Roget remarks, that "the greater the energy with which the more peculiarly animal functions of sensation and muscular action are exercised, the greater must be the demand for nourishment, in order to supply the expenditure of vital force created by these exertions. Compared with the torpid and sluggish reptile, the active and vivacious bird or quadruped requires, and consumes, a much larger quantity of nutriment. The tortoise, the turtle, the toad, the frog, and the chameleon, will indeed live for months without taking any food." "The rapidity of development," he continues, "has also great influence on the quantity of food which an animal requires. Thus, the caterpillar, which grows very quickly, and must repeatedly throw off its integuments, during its continuance in the larva state, consumes a vast quantity of food compared with the size of its body; and hence we find it provided with a digestive apparatus of considerable size."* The quantity of food which some animals are capable of assimilating is almost incredible, especially when they are small (the loss of animal heat being then comparatively great), and are at the same time very lively. Both of these conditions are united in the mouse, and accordingly we find, from the experiments of Philippi, that, in twenty-four hours, one weighing 18·73 grammes consumed 7·36 grammes, or more than the third of its weight, of bread, and gave off, in same time, 6·83 grammes of insensible exhalations.† Valentin, in repeating these experiments, found that the carbonic acid given off daily, was equivalent to a fifth of the weight of the animal experimented upon.* In the caterpillar, the sensible evacuations are bulky in proportion to the food consumed, as the latter contains a large quantity of indigestible woody fibre; but, in the mouse, the amount of transpiration is found to be more than six times the amount of the urinary and alvine evacuations. These results are truly astonishing, and can be explained only on the supposition that the animals rapidly lose heat by radiation, and that their functions are carried on with intense energy. The movements of the mouse are indeed very rapid, and we need only to reflect on the liveliness displayed by this little creature in its rotatory cage, and the expenditure of power thus occasioned, to see how an ample supply of nourishment may be rendered necessary.

In insisting so emphatically on regular bodily and mental activity, and frequent exposure to the open air, as indispensable to the enjoyment of a good appetite and sound digestion, I trust the attentive reader will not be disposed to accuse me of inconsistency because, when treating of muscular exercise in a former work,† I explained the bad effects, and inculcated the impropriety, of indulging in any considerable exertion *immediately before or after a full meal.* It is true, as there mentioned, that exercise, either in excess or at an improper time, impairs the tone of the stomach; but it is not on that account the less true, that bodily exertion, when seasonably and properly practised, is the best promoter of appetite and digestion which we possess; and it is only under the latter conditions that I now speak of it as beneficial, and even indispensable, to health. In a work like the present, it is obviously impossible to fence round every general proposition with the limitations which an unusual combination of circumstances, or a departure from the state of health, might demand. And, even if possible,

* Roget's Bridgewater Treatise on Animal and Vegetable Physiology, vol. ii., p. 112.
† Experimenta de Murium Respiratione et Nutritione. Lipsiæ, 1845.

* Lehrbuch der Physiologie, vol. i., p. 731.
† Principles of Physiology, &c., chap. iv. and v.

it would not be necessary, as the laws of exercise have been so fully explained in the work alluded to, that their re-discussion here would unavoidably involve much repetition of what has already been stated in its pages. At the same time, some warning remark may be required to prevent any risk of misconception; as it might otherwise be plausibly argued, for example, that there can be no such relation as I have alleged between waste and appetite, because a European perspiring under a tropical sun incurs great waste, and yet loses both appetite and digestive power. To render this a valid exception, it must be shewn that the European is intended by Nature to live in a tropical climate, and that the diet to which he accustoms himself is that sanctioned by experience as the best adapted to his constitution under the influence of such a climate; because, if neither be the case, his condition must necessarily be more or less closely allied to the state of disease, and therefore be beyond the sphere to which alone my remarks are meant to apply. But even in that instance there is less contradiction than may be imagined; for the waste of the system, being chiefly fluid, excites, not hunger, but its kindred sensation, thirst, to repair the loss by an unusual demand for refreshing liquids. It must be recollected also, that in tropical countries the loss of animal heat is very small, and consequently little food is required to replace it. This is the true explanation of the diminished appetite experienced in warm climates.

So true is it that the Creator has established a relation between action and nutrition, that when we attempt for any length of time to combine a full and nutritious diet with systematic inactivity, the derangement of health which ensues gives ample proof of the futility of struggling against His laws. Certain individuals, indeed, may be met with, who, from some peculiarity of constitution, such as large lungs, suffer less than the generality of mankind from making the experiment; but even those among them who escape best, generally owe their safety to the constant use of medicine, or to a natural excess in some of the excretory functions, such as perspiration or the urinary or alvine discharges, by means of which the system is relieved much in the same way as by active exercise; and hence the remark made by Hippocrates, that severe perspirations arising during sleep, without any other apparent cause, are a sure sign that too much nourishment is made use of. In others, again, the day of reckoning is merely delayed, and there is habitually present a state of repletion, which clogs the bodily functions, and may lead to sudden death by some acute disease when the individual is apparently in the highest health. I am acquainted with several individuals of this description, who, in the absence of bodily exercise, are accustomed to live very fully,—to eat in the morning a hearty breakfast, with eggs, fish, or flesh,—a good solid luncheon, with wine or malt liquor, in the forenoon,—a most substantial dinner, with dessert and several glasses of wine, and afterwards tea, and wine and water in the evening,—and who nevertheless enjoy tolerably good digestion. But this advantage is in general only temporary, and even while it lasts can scarcely be considered as a boon; because it is gained at the direct expense either of a very full habit of body and an unusual liability to abdominal congestion and all its attendant evils, or of frequent and profuse perspirations, and severe attacks of bowel-complaint, endangering life; so that, strictly considered, such cases are far from being exceptions to the general rule.

It is, then, no idle whim of the physician to insist on active exercise as the best promoter of appetite and digestion. Exercise is, in fact, the condition without which exhalation and excretion cannot go on sufficiently fast to clear the system of materials previously taken in; and where little waste is incurred, little need of a fresh supply, and consequently, in the healthy state, little natural appetite, can exist. It is, therefore, not less un-

reasonable than vain for any one to insist on possessing, at the same time, the incompatible enjoyments of luxurious indolence on the one hand, and a vigorous appetite, sound digestion of a hearty meal, and general health of body, on the other; and no one who is aware of the relation existing between waste and appetite can fail to perceive the fact, and to wonder at the contrary notion having ever been entertained.

Among the operative members of the community we meet with innumerable examples of an opposite condition of the system, where, from excess of labour, a greater expenditure of organic substance takes place than the scanty diet is able to repair. It is true that the disproportion is generally not sufficient to cause that immediate wasting which accompanies actual starvation; but its effects are nevertheless very palpably manifest in the depressed buoyancy, early old age, and shorter lives, of the labouring classes. Few, indeed, of those who are habitually subjected to considerable and continued exertion, survive their forty-fifth or fiftieth year. Exhausted at length by the constant recurrence of their daily task and imperfect nourishment, they die of premature decay, long before attaining the natural limit of human existence.

In those states of the system, again, such as fever, during the continuance of which most of the secretions are lessened, and that of the gastric juice often entirely suspended, and where food would consequently be hurtful rather than advantageous, appetite is scarcely felt, and loathing often occupies its place. But the moment that, by the diminution of the disease, the secretions and exhalations begin to return to their healthy state, and nutrition is resumed, appetite begins to be again felt, and by and by becomes abundantly vigorous, in order to restore the system to its former state. The utmost caution, however, is still required in its gratification, as a premature indulgence is almost certain again to stop the secretions and to produce a relapse. Ignorance of this principle among the community at large, and the consequent error of giving food when there is no demand for it, and no gastric juice to digest it, often do more to defeat the best laid plans of cure than the severity of the disease itself. The sick man's friends, in their anxiety to support his strength, too frequently turn a deaf ear to every caution which is suggested, and stealthily administer sustenance when the system does not require it, and when it serves only to aggravate the danger and increase the weakness of the patient. Since the first publication of the preceding passage, I have seen a striking example of its truth. The patient was gradually recovering from inflammation of the chest, for the cure of which low diet was for a time indispensable. By way of *supporting the diminished strength*, the relations began to give, prematurely and clandestinely, about double the quantity of food which was prescribed. For twenty-four hours, an increase of strength was felt accordingly; but very soon it passed into febrile excitement with a quick pulse and *increased weakness*. A dangerous relapse followed, and its cause was then discovered. Abstinence was again enforced, and tartar emetic given to excite nausea. To the surprise of the very injudicious relatives, the excitement began almost immediately to subside, and the strength to improve, where they had just seen it fast giving way under a full diet.

If the purposes for which eating is necessary be kept in mind, the keen appetite and vigorous digestion observable in growing youths, and in those who undergo much active exercise in the open air,—and the weaker appetite and feebler digestion observed during the middle period of life, especially in persons of sedentary habits,—will appear to be in strict harmony with the wants of the system in the respective circumstances. But from ignorance of the principle by which the supply of nourishment should be regulated, and from the haste with which every one labours to appease the cravings of hunger, it may be affirmed as a general fact, that persons in easy circumstances eat greatly

more than is required for their sustenance; and the indigestion thereby induced is often a salutary provision of Nature to prevent the repletion which would otherwise ensue.

Sir Francis Head, in his humorous book entitled *Bubbles from the Brunnens of Nassau, by an Old Man*, expresses his astonishment at the "enormous quantity of provisions" which the invalids and sojourners at these watering-places "so placidly consume;" and after noticing "the heavy masses which constitute the foundation of the dinner, and the successive layers of salmon—fowls—puddings—meat again—stewed fruit—and, lastly, majestic legs of mutton—which form the lighter superstructure," he adds: "Nothing which this world affords could induce me to feed in this gross manner. The pig which lives in his sty would have some excuse, but it is really quite shocking to see any other animal overpowering himself at mid-day with such a mixture and superabundance of food."—(P. 71.) In another page he returns to the subject, and quaintly enough remarks, "that almost every malady to which the human frame is subject is, either by high-ways or by-ways, connected with the stomach; and I must own I never see a fashionable physician mysteriously counting the pulse of a plethoric patient, or with a silver spoon on his tongue, importantly looking down his red inflamed gullet (so properly termed by Johnson 'the meat-pipe'), but I feel a desire to exclaim, 'Why not tell the poor gentleman at once—Sir, you've eaten too much, you've drunk too much, and you've not taken exercise enough!' That these are the main causes of almost every one's illness, there can be no greater proof than that those savage nations which live actively and temperately have only one great disorder—death. The human frame was not created imperfect—it is we ourselves who have made it so; there exists no donkey in creation so overladen as our stomachs, and it is because they groan under the weight so cruelly imposed upon them, that we see people driving them before them in herds to drink at one little brunnen."—(P. 91-2.)

Our supposed "Old Man" is by no means singular in his opinions. The celebrated Roman physician Baglivi, who, from practising extensively among Catholics, had ample opportunities of observation, mentions that, in Italy, an unusually large proportion of the sick recover during Lent, in consequence of the lower diet which is then observed in the fulfilment of their religious duties. This fact is at once a testimony in favour of temperance, and a proof of the assertion that excess in quantity is a prevailing error in society.

Professor Caldwell, of the United States, in one of his vigorously-conceived and very instructive essays, inveighs eloquently against the intemperance of his countrymen in eating as well as in drinking, and tells them that one American consumes as much food as two Highlanders or two Swiss, although the latter are among the stoutest of the race. "Intemperate eating," says he, "is perhaps the most universal fault we commit. We are all guilty of it, not occasionally, but habitually, and almost uniformly from the cradle to the grave. It is the bane alike of our infancy and youth, our maturity and age. It is infinitely more common than intemperance in drinking; and the aggregate of the mischief it does is greater. For every reeling drunkard that disgraces our country, it contains one hundred gluttons—persons, I mean, who eat to excess, and suffer by the practice." "How, indeed," he afterwards exclaims, "can the case be otherwise, while children and youth are regularly taught, hired, bribed, or tempted, to over-eat themselves from their birth! Do you ask me for evidence in proof of this charge? Go to our dining-rooms, nurseries, fruit-shops, confectionaries, and pleasure-gardens,—go even to sick-rooms,—and you will find it in abundance. You will witness there innumerable scenes of gormandizing, not only productive of disease in those concerned in them, but in many instances offensive to be-

holders. The frightful mess often consists of all sorts of eatable materials that can be collected and crowded together; and its only measure is the endurance of appetite and the capacity of the stomach. Like the ox in rich pasture-ground, or the swine at his swill-trough, men stow away their viands, until they have neither desire nor room for any more. I do not say that such eating-matches always and everywhere occur among us. But I do say that they occur too frequently, and that they form fit subjects for caricature pictures, by European tourists, of our domestic manners. I add, however, that similar scenes present themselves in every country I have visited, where provisions are abundant and cheap."*

This is a strongly-drawn picture, but, with a modification in degree, it is perhaps not less applicable to our own and other European countries than to the United States. The "Old Man's" description of German feeding is in its main features essentially the same; and, so far as my observation and experience go, it is only in a less degree that we fall short of our brethren in America. As a general rule, we also exceed, though not to the same extent. This is owing partly to our more advanced civilization, and partly to the greater difficulty of procuring the means of excess; and if I have resorted to Germany and the United States for the most striking illustrations of the principle, it is not for want of examples at home, but because we are so much more alive to the errors of our neighbours than to our own, that the principle involved in their commission will be more readily recognised when pointed out in foreigners, than when its perception is made to imply condemnation of ourselves.

It is a trite observation, that medical men are constantly exclaiming against the eating propensities of their patients, and inculcating the practice of temperance. A late eminent physician says: "I believe that every stomach, not actually impaired by organic disease, will perform its functions if it receive reasonable attention; and when we consider the manner in which diet is generally conducted, both in regard to quantity and to the variety of articles of food and drink which are mixed up into one heterogeneous mass, instead of being astonished at the prevalence of indigestion, our wonder must rather be, that, in such circumstances, any stomach is capable of digesting at all. In the regulation of diet, much certainly is to be done in dyspeptic cases, by attention to the quality of the articles that are taken; but I am satisfied that *much more depends upon the quantity;* and I am even disposed to say, that the dyspeptic might be almost independent of any attention to the quality of his diet, if he rigidly observed the necessary restrictions in regard to quantity."* The latter opinion, which is in perfect harmony with Dr Beaumont's observation of the power of digestion being limited by the amount of gastric juice which the stomach is capable of providing—an amount varying with the wants of the system, and, consequently, with the mode of life—is also forcibly though quaintly supported by a late popular writer, who affirms that "it is your superfluous SECOND COURSES"—"(which are served up more to gratify the pride of the host than the appetite of the guests)—that *overcome the stomach* and *paralyze* digestion, and seduce children of larger growth to sacrifice the health and comfort of several days for the baby-pleasure of tickling their tongues for a few minutes with trifles and custards."†

Cornaro, Cheyne, and others, have, most absurdly, attempted to determine a standard quantity of food for all mankind, and have fixed it at the lowest possible limit. The very attempt, however, sets at defiance the laws of the animal economy; since the supply required must necessarily vary not

* Transylvania Journal of Medicine for September 1832, p. 313. See also Dr Caldwell's excellent "Thoughts on Physical Education, and the True Mode of Improving the Condition of Man;" reprinted in a cheap form for Maclachlan, Stewart, and Co., Edinburgh, 1844.

* Abercrombie on Diseases of the Stomach, &c. 1st edition, p. 72.

† The Art of Prolonging and Invigorating Life, 3d edition, p. 168.

only according to the age, sex, and constitution of the individual, but according to the mode of life and the circumstances by which he is surrounded—and it would therefore be not less injurious than unnatural for any one to adhere to the same invariable proportion. I have seen several instances in which young men have suffered considerably from adopting for a time the low scale of diet recommended by Cornaro, or from living exclusively on vegetables, without regard to the urgent demand for a full supply of nourishing food consequent on their time of life, and rendered more necessary by the active bodily exertion in which they engaged.

Mixtures of different kinds of food are strongly condemned by almost all writers on dietetics, as injurious to digestion. They seem to me, however, to produce mischief much more by the *inducement to excess in quantity* which variety affords, than by the mere mixture of different substances. In a healthy stomach, indigestion is rarely if ever induced by eating several kinds of food at one meal, provided the total amount consumed be not beyond the wants of the system, and do not exceed the due proportion to the quantity of gastric juice which the stomach is able to provide. When only one dish is partaken of, there is less temptation to exceed in quantity than where several are tasted.

The first intimations of satisfied appetite are unquestionably the best warning we can have when to stop eating. If we do not go beyond this point, the subsequent sensations are pleasurable and invigorating, and, after a brief interval, we are perfectly disposed to return to active exertion. But if we eat more than enough, fulness and oppression are almost immediately experienced, and a considerable time must elapse before either mind or body can effectually resume its activity.

Where, from long over-indulgence or other causes, the appetite cannot be safely followed as a guide in regulating the quantity of food, we shall not err very far if, with due regard to the season of the year, we proportion our meals to the amount of the preceding exercise. When this has been active and in the open air, and waste has consequently been considerable, a liberal allowance of food will be more easily digested than perhaps half the quantity would be after a week's inaction. Hence, it is a great error to devour the same quantity of food daily, in summer and in winter, and whatever our mode of life and bodily exertion may be; because "the strong food which the strong action of strong bodies requires will soon destroy weak ones, if the latter attempt to follow the example of the former: instead of feeling invigorated, their stomachs will be as oppressed as a porter is with a load that is too heavy for him—and under the idea of swallowing what are called strengthening, nourishing things, will very soon make themselves ready for the undertaker."* And yet nothing is more common than to see persons who have passed from a life of varied activity in the open air to one of a purely sedentary nature within doors, continue to eat—merely because they have been accustomed to it—as much food as if they were still engaged in constant bodily exertion. Many females of the higher and middle classes, who scarcely ever stir out of doors except to church, nevertheless make as hearty meals twice or thrice a-day as if they were undergoing pretty severe exertion; but they sooner or later reap their reward, and after groaning for a time under the burden which they have placed upon their own shoulders, they either obtain relief by the forced adoption of a temperate regimen, or "fall into the hands of the undertaker."

In towns, we often observe the bad effects of over-feeding in young female servants, recently arrived from the country. From being accustomed to constant exercise and a low temperature in the open air, and to the comparatively innutritious diet on which the labouring classes subsist, they pass all at once, with appetite, digestion, and health in their fullest vigour, to

* Art of Prolonging, &c., p. 171.

the confinement of a warm house, the impure atmosphere of a crowded city, and a rich and stimulating diet. Appetite, still keen, is freely indulged; but waste being diminished while nutrition is increased, fulness is speedily induced, followed in its turn by inflammatory disease or fever, which sometimes cuts short life, where, with better management, health might have been preserved for years. In many instances, again, life is saved by the digestive powers being the first to give way, and refusing either to receive or concoct the same quantity of aliment as before, and the patient then escapes with the minor evils of protracted indigestion. This latter result ensued in an instructive case mentioned by Heidler, where a moderate acquaintance with the laws of the animal economy might have saved months of suffering, and even of danger, to the patient.—"A young woman of a healthy constitution, brought up in all the simplicity of country habits, passed at once, on her marriage, to a *less active mode of life*, and to a *much more elegant table*. In a short time she began to complain of irritability, lassitude, various spasmodic sensations, and habitual constipation. Hypochondria was soon added to the other symptoms; her hope of becoming a mother being always deceived, an additional glass of wine, bark, and other tonics, were ordered. The evil increased. The patient became melancholic, and believed that she was always swallowing pins. In the course of the year, she became so emaciated and yellow, that her mother, who had not seen her for eleven months, could scarcely recognise her. After an eighteen months' course of purgatives, and two courses of Marienbad water, she entirely recovered."* If the medical adviser first consulted in this case had possessed the slightest acquaintance with the principle I have been explaining, he would no more have regarded wine and tonics as the best remedies for the oppressive languor of inordinate feeding, than he would have sought to extinguish a fire by pouring oil into the flame.

The operation of the same principle is equally conspicuous in girls sent from the country to the work-rooms of fashionable milliners and dressmakers in the larger towns. Accustomed to constant and varied activity in the open air, they are transferred at once to confinement all day, and even till a late hour at night, in the heated and impure atmosphere of a crowded work-room, and there engaged in sedentary occupations of the most monotonous description, which, so far from allowing them any opportunity of enjoying adequate muscular exercise, scarcely admit of their even changing their position. Under such circumstances little waste takes place, and the appetite and digestive powers both give way, because less food is now required to repair the diminished loss. If the individual adapt her eating to her change of circumstances, she may escape severe disease; but if, as generally happens, she, from pure ignorance, continue to eat to the same extent as before, headaches, sickness, bilious disorder, and indigestion, will be among the smallest of her evils, and she will have reason to be thankful if she do not become the victim of confirmed bad health. Another, and still more serious source of danger, however, is the length of time during which the work is carried on. From recent inquiries, it appears that, in the busy season, from 16 to 20 hours' work in a crowded and ill-ventilated room, is the daily task allotted to the young dressmakers of the metropolis, and that frequently they are compelled to work all night even for two or three days in succession. This is a frightful state of bondage, and very little is done to alleviate it; and yet, even independently of the abridgment of the hours of work which is obviously indispensable, the simple provision in establishments of this description, of the means of recreative exercise by dumb-bells, shuttlecock, or otherwise, *in a large room with open windows*, for a few minutes several times a-day, would both diminish the

* Heidler, Marienbad et ses differens Moyens curatifs dans les Maladies Chroniques, p. 62.

amount of suffering, and compensate for the time expended, by producing an increased aptitude for work, and less frequent absence on account of illness. In these days of wide-spreading philanthropy, considerations of this kind ought to be more attended to than they are.

The necessity of proportioning the supply of food to the expenditure incurred and to the mode of life, is still further illustrated in the case of individuals changing from an agricultural or other employment carried on in the open air in the country, and involving no very great bodily labour, to one of a mechanical kind carried on in a close atmosphere in a city, and requiring severe and continued muscular exertion. It is a matter of experience, for example, that the stout young men from the country, who are generally selected as apprentices for the laborious occupation of letter-press printing, almost uniformly break down during the first ten or twelve months, and it is only after some years' training that they are able to withstand the fatigue. The vitiated atmosphere in which they work has some share in producing this result, but the chief cause is undoubtedly the inadequacy of their ordinary diet to repair the great expenditure of muscular substance to which they are habitually subjected, and for which they have not been previously prepared. In the office where this volume is printed, four strong and healthy lads were engaged in the summer of 1835 as pressmen, and put to work along with an equal number of experienced men. Before the following February every one of the former had been laid up from sickness for weeks, although the whole of them were of the most sober and steady habits; while not one of the older and more experienced men felt any inconvenience from his exertions. During the continuance of growth, more ample supplies of food are necessary than at a later period; and herein consists one important reason why lads suffer from an amount of fatigue which older men undergo with impunity, the diet of both being alike. The above very instructive fact is besides deserving of attention, as corroborating what I have elsewhere said in regard to the necessity of proper management at the period of transition from youth to manhood—a period during two or three years of which more good or more mischief may be done to the human constitution than during almost any other ten years of life.* That, in times past, pressmen have suffered at least as much from their own mismanagement as from the nature of their employment, is rendered probable by their proverbial dissipation. In utter ignorance of the structure and laws of the animal economy, they naturally sought to relieve the exhaustion under which they suffered, by the stimulus of spirits and other intoxicating liquors, instead of seeking it—where only it can be effectually obtained, and at a cheaper rate—in a more wholesome and nourishing diet. It is gratifying to perceive, however, that in this, as in many other trades, the progress of knowledge is already leading to the prevalence of more rational views, and to the formation of better habits.

There is no period of life during which it is of greater importance to conform to the intentions of Nature in the regulation of diet, both as to quantity and quality, than during the earliest part of childhood; for at no period is the neglect of them more fatal. Surprise is sometimes expressed at the number of children who are carried off before completing their first or second year; but when we consider the defective education, and entire ignorance of the human economy, not only of the nurses and servants to whose care the young are entrusted, but of the parents themselves, our wonder ought to be, not that so many die, but that so many survive. There is perhaps not one mother in ten thousand, who, before becoming such, has ever inquired into the nature and wants of the newly-born infant, or knows on what principles its treatment ought to be directed; and hence the hurtful and superstitious notions

* Principles of Physiology, &c., 13th edition, chap. x., p. 290, and chap. xiii.

concerning the human economy which still linger in the nursery, long after they have ceased to prevail in the world of science.

Those whose opportunities of observation have been extensive will agree with me in opinion, that at least one-half of the deaths occurring during the first two years of existence are ascribable to mismanagement and to errors in diet. From pure ignorance, many mothers consider every expression of uneasiness as an indication of appetite, and whenever a child cries they offer it the breast again, although ten minutes may not have elapsed since its preceding repast. Nothing can be more injurious than this custom. It overloads and oppresses the stomach, excites griping and bowel-complaints, restlessness and fever, and not unfrequently leads to fatal disease in the brain. It does harm also by withdrawing the mother's attention from the real source of uneasiness.

It is astonishing, indeed, with what exclusiveness of understanding eating is regarded even by intelligent parents as the grand *solatium* or *panacea* for all the pains and troubles which afflict the young. If a child falls over a stone and bruises its leg, its cries are immediately arrested by a sugar-biscuit stuffed into its open mouth. If its temper is discomposed by the loss of a toy, it is forthwith soothed by an offer of sweetmeats, the ultimate effect of which is to excite colicky pains in its bowels, which are worse than the original evil, and for which, in their turn, it is presented with "nice peppermint drops," or some other equally pleasant antidote. Because the mouth is open when the child is crying, and the mouth leads to the stomach, parents seem to think that it is open only for the purpose of being filled, and proceed to cram it accordingly; forgetting all the while that the mouth leads also to the wind-pipe, and may be open for the admission of air to the lungs as well as of food to the stomach, —and that if they stuff it with cake or pudding when it is open for the inhalation of air, they run the risk of suffocating the little innocent when their wish is merely to soothe him. Everybody must have seen fits of convulsive cough induced by fragments of food being drawn into the windpipe in such circumstances.

To confound crying and the expression of pain with the cravings of hunger, is far from being a matter of indifference to the child. If food be given when it wishes only to be relieved from suffering, the offending cause is left in activity, and its effects are aggravated by the additional ill-timed distention of the stomach. But so far is this important truth from being sufficiently impressed on the minds of parents and nurses, that nothing is more common, when the infant refuses to swallow more but still continues to cry, than to toss it in the nurse's arms as if on purpose to shake down its food, and then resume the feeding. And in such irrational attempts, the perseverance of the nurse often gets the better of the child, and forces it at last to receive the food which it really loathes.

In former editions of this work, I took considerable pains to point out the principles according to which diet ought to be regulated during the first months of life; but as the subject has since been very fully discussed in my *Treatise on the Physiological and Moral Management of Infancy*, I think it unnecessary to enter into further detail here.

That the prevalence of over-eating is a general error in society, especially among the sedentary classes, is strongly presumable, even without direct proof, from two almost characteristic circumstances—namely, the frequency of indigestion in one or other of its numerous forms, and the almost universal use of purgative medicines, with a view to remove from the system the superfluous materials which have been poured into it without any natural demand.

It is certain that, in the natural state of man, the bowels are quite able to act regularly without the aid of laxatives. If they are not, the Creator must have failed to accomplish his aim—a conclusion which no rational mind can arrive at. If, on the other

hand, they are intended and constituted to act without external aid, it necessarily follows that a wide departure from the order of nature must have taken place somewhere, to produce the inactivity which is now so generally complained of, especially among the middle and higher classes, and among females. On the principle we have laid down, that nourishment requires to be proportioned to waste, it will not be difficult to explain in what this departure consists. It is in the mode of life being by far too sedentary to admit of a sufficiency either of the natural waste, which alone renders nourishment necessary, or of that constantly-recurring contraction and relaxation of the abdominal and respiratory muscles, which has been pointed out as aiding so effectually the peristaltic motions of the intestinal canal. If, in conformity with the diminished wants of the system, we reduce the quantity of food and increase the exercise, neither the oppression of repletion nor the need of opening medicine will be felt. But if, along with diminished exhalation and diminished muscular action, we persevere in eating copiously of nutritious aliments, either digestion must fail, the system become too full, or some artificial stimulus be given to aid the bowels in expelling their superfluous contents.

Such, accordingly, are the results observable in everyday life. One man is saved for a time from more serious evils by his stomach becoming enfeebled, and refusing to digest the excess of nourishment which it receives. In another, whose digestion is more vigorous, the system becomes full and excited to the brink of active or inflammatory disease, a sudden attack of which hurries him to the tomb. While a third gets rid of the load by stimulating the bowels to higher action than is natural to the mode of life ; in other words, artificial waste is excited by purgatives, to supply the place of that which ought to result from the active use of the bodily powers, and which alone renders a full diet proper or safe.

It is not enough, then, to sit by the fire, blame Nature, and lament over our unfortunate constitution, which obliges us to make such constant use of medicine. In the great majority of instances, Nature is more willing to do her part than we are to do ours, and all that she requires of us is to fulfil those conditions without whose observance she is powerless, and we are unhappy sufferers. If we exercise our minds and bodies in healthful occupation, and seek to inhale the pure atmosphere which God has spread around us, so as to impart to the stomach and bowels that gentle impulse which I have already described as necessary to their proper action, we shall have no need of laxatives to assist them. But if we choose to live in bodily inaction within doors, and thus deprive the bowels of all natural aid, let us at least take the blame to ourselves, and not unjustly throw it upon the Ruler whose injunctions we thus practically despise. And if, while leading this inactive life, we continue to gratify taste by eating much more than waste requires, and thus stand in need of purgatives to enable us to throw off the load, let us at least be just, and, instead of lamenting over a defective constitution, let us deplore the ignorance which has hitherto blinded us to the perception of the truth, and led us to blame a Being whose arrangements are so evidently intended for our happiness.

During the active years of childhood and youth, when a strong instinct impels to much locomotion in the open air, how rarely do we find the stimulus of purgatives necessary to the proper action of the bowels, except after errors in diet, or some unusual accident! And what is it that induces imperfect activity in later years, if not the change in the habits, occupations, and mode of life? If the lively and bounding girl, whose loose and unconstrained attire admits of the freest motion and fullest respiration, passes in a few months from the exuberant and playful indulgence of her feelings, intellect, and muscular system, to the quiet and composed inaction and confined dress of a sedate young lady, who never walks out, ex-

cept at a measured pace to school or church, is it at all wonderful, that, with an undiminished diet, her stomach and bowels should begin to act with less vigour, and that, in time, her constitution should be so far impaired, as to render necessary the constant use of laxatives? The stomach and bowels, in fact, are regarded very much as if they were independent powers residing within us, and placed there purposely for our molestation. So many heavy charges are continually brought against them, that they can scarcely ever be found in the right. They are blamed for every act of mischief which cannot be clearly proved against any other organ; and yet, influential as they are in affecting our comfort, they are treated by us with very little care or ceremony. Their powers and wishes are consulted in nothing, but their backs are loaded, at the caprice of their owners, worse, as Sir F. Head observes, than any pack-horse; nevertheless we abuse them most emphatically when they sink to the earth overwhelmed by the weight imposed on them. They are, in short, the scape-goats which must bear all our physiological delinquencies, and save us the pain of blaming ourselves. If they feel uneasy after a heavy meal, it is not *we* who are to blame for having eaten it. Oh no! it is the *fish* which lies heavy on the stomach, or the stomach which is unfortunately at war with the soup, or potatoes, or some other well-relished article. *We* have nothing to do with the mischief, except as meek and resigned sufferers. *We* never eat more than enough. *We* never devour lobsters, or oysters, or salmon, or cheese, or any thing which experience has told us our enfeebled stomachs cannot digest! We are too prudent and self-denying for that. And yet, somehow or other, our stomachs get hold of all these things in spite of us, and we must pay the same penalty as if *we had* eaten them deliberately, and with malice prepense! The case is hard, no doubt, that we cannot lead indolent and slothful lives, and yet enjoy the incompatible luxury of having the appetite of a rustic and the digestion of a tiger;—but since we are so unfortunately constituted, that we must act like rational creatures or suffer the penalty, would it not, after all, be a wise proceeding to set a better watch on the stomach, and try to subject it to more effectual control?

In mature and middle age, after the effervescence and boisterous activity of youth are over, still greater caution than before becomes requisite. Growth being now finished, nourishment is needed merely to repair waste; and accordingly the appetite becomes less keen, and the power of digestion less intense. As already mentioned, if the individual, even after changing to a sedentary mode of life, continue from habit to eat as heartily as before, the natural vigour of the digestive system may enable it to withstand the excess for a time; but ultimately dyspepsia, or some form of disease dependent on indigestion, will certainly ensue. The attempt to combine the appetite and digestive power of early youth with the altered circumstances and comparative inactivity of mature age, is the true source of the multitude of bilious complaints, sick-headaches, and other analogous ailments, now so common and so fashionable in civilised society; and they will never be got rid of so long as their causes are allowed to operate with unrestricted freedom.

There is one form in which adults pay a very heavy penalty for attempting to combine the enjoyments of full living with an inactive mode of life, and to which, from its frequency, it may be useful to direct special attention. I allude to *abdominal congestion*, or that state in which the circulation through the abdominal veins becomes sluggish, or partially obstructed, and ultimately induces either chronic indigestion with great depression of mind, or other affections of a painful and intractable nature. In the great majority of instances, this is the true source of the very common affection known by the name of *internal piles*, which not only is the frequent cause of much suffering and bad health,

but, when once fully established, can be cured only by one of the most painful operations within the whole province of surgery.

But while habitual temperance in eating, and the adaptation of diet to the mode of life, are thus strongly inculcated, I am far from recommending that we should calculate with scrupulous minuteness the weight or bulk of every morsel that we eat. The stomach, like every other organ of the body, is, for the wisest purposes, allowed a certain range, within which it may exercise its functions without injury to health; and it is only in virtue of such a power, that it can adapt itself to the different circumstances in which an individual may be placed. If every trifling change in the quantity or quality of food were to be followed by mischievous consequences, no one could retain health for a single day; and if the stomach had no power of partially adapting itself to a particular kind of aliment, every change of place and of climate must soon have been attended by the loss of health and life; because there are scarcely any two places or countries in which precisely the same food would be set before us.

According to this law of adaptation, which, of course, has its limits, the stomach may be accustomed to the reception of either a larger or a smaller quantity of food than the necessities of the system require. If it be accustomed to too much, and less than usual be allowed, an unpleasant feeling of vacuity will arise, accompanied by a craving for more; but after a few days the unpleasant sensation will cease, and the feeling of satisfaction be as great as if a large meal had been taken, and digestion will become more healthy and vigorous; whereas if, merely to gratify the temporary craving, more food continue to be taken than the system requires, ultimate bad health will be the inevitable result.

This is precisely the error which is generally fallen into. The stomach is accustomed during youth, in order to carry on growth and repair the ordinary waste of the system, to receive and digest a larger quantity of food than is requisite after maturity has been attained.* From custom, however, we continue to fill it as liberally after growth is completed and waste is diminished, as we did before, when both were at their height. And if by any chance we eat less for a day or two, we mistake the temporary sense of emptiness for an indication of appetite, and are not satisfied till it is removed. The natural consequence is, that we educate the stomach to demand more food than the system requires, and more than it can itself continue to digest; and hence the numerous evils which we daily witness as fruits of indigestion.

In thus afflicting us with the pangs of dyspepsia as a warning to more reasonable conduct, Providence displays the purest beneficence. To place this in a clear point of view, let us suppose digestion to continue perfect, notwithstanding the daily reception of an excess of food into the stomach: the result will necessarily be the regular formation of an undue quantity of nutritive chyme; this, in its turn, will produce an excess of blood throughout the whole system; and the individual will thus exist with all his functions in a state of constant oppression, and in continual danger of the rupture of a bloodvessel, till, from mere fulness, some active disease will be excited, requiring the instant and vigorous use of the lancet for its relief, or very probably cutting short life. If, then, we cannot subject our appetites to the control of reason, some other check against repletion must be provided; and, fortunately for us, such a check is frequently found in the refusal of the stomach to continue to digest the superfluity of food. In practical life we meet, in fact, with both results. Some persons are constituted

* In early youth, the quantity of carbonic acid given off by the lungs is, weight for weight, much greater than in maturity, and double that given off in old age. If, therefore, we regard the carbonic acid as an indication of the quantity of food necessary for the support of the body, it follows that a youth weighing 100 lbs. will require double the allowance of an old man of like weight. The reader will at once perceive the application of this fact to the case of the printers mentioned on p. 98. For the data on which these calculations are founded, see Valentin's Lehrbuch, vol. I., p. 585.

with such vigorous powers of digestion, that no quantity of food ever seems to oppress their stomachs. If they eat habitually more than is required to repair waste, generate heat, and sustain the system, they speedily suffer from repletion, or some one or other of the diseases arising out of its existence—such as abdominal obstruction, piles, inflammation, apoplexy, hæmorrhage, enlargement of the heart, or morbid growth in some organ of the body. In the greater number, however, of those who exceed in quantity, the stomach itself becomes enfeebled by the over-exertion to which it is subjected; it ceases to secrete the gastric juice in due quantity, and of proper quality; and the consequence is impaired digestion, which prevents the food from being duly converted into blood, and thus protects the system from the fulness which would otherwise be induced. Accordingly, it is a familiar truth, that those who eat most are not always the best nourished—and that, on the contrary, the most corpulent men are often those who eat comparatively little, but by whom that little is thoroughly digested.

It is, therefore, of great importance to be able to read aright the instructions of Nature, and to act in conformity with their meaning. In practical benefit to ourselves, it will make a great difference whether we regard indigestion as merely an accidental and capricious occurrence unconnected with conduct, or as meant to warn us from continuing to act against laws instituted to secure our well-being and happiness. In the former case, we may go on unsuspectingly in the road to destruction till it is no longer in our power to turn back; whereas, in the latter, we cannot feel a single pang of indigestion without being reminded of some aberration from the path of duty, and seeking to return by the shortest way. It is too true that, even when aware that we are going wrong, we do not always choose to retrace our steps; but it is not less true, that we shall be more likely to fulfil the laws of Nature when we are made acquainted with their existence and intention, than when left in ignorance. It must be observed also, that hitherto mankind have not been taught the requisite knowledge till after their habits of action were formed; and therefore no inference drawn from their conduct in circumstances so unpropitious, can fairly be held as applicable to the time when such knowledge shall be communicated to the young as an indispensable part of a useful education.

If over-feeding be the prevailing error among the middle and higher classes of the community, the opposite condition, as I have already observed, is as unquestionably that of a large proportion of the labouring poor. Pressed upon all sides by the powerful competition of constantly improving machinery and a superabundant population, the manual labourer is impelled to undergo an amount of ever-recurring bodily exertion, which often far exceeds the natural powers of his constitution, even if supported by the fullest supply of nourishment;—and when (as often happens), along with this excess of labour, his food, from inadequate wages, the number of his family, or his own injudicious management, is defective in quantity or quality, the consequences to his health and happiness are disastrous in the highest degree.

To those who have never reflected on the subject, it may seem like exaggeration to say, that, as a general fact, at least nine-tenths of the lower orders suffer physically, morally, and intellectually, from being over-worked and under-fed; and yet I am convinced, that the more the subject shall be investigated, the more deeply shall we become impressed with the truth and importance of the statement. It is true that very few persons die from direct starvation, or the absolute want of food for several successive days; but it is not less certain that thousands upon thousands are annually cut off, whose lives have been greatly shortened by excess of labour and deficiency of nourishment. This is especially the case when the price of provisions is high, and employment diffi-

cult to be had. In the Fifth Report of the Registrar-General to Parliament, of the births, marriages, and deaths in England and Wales, the connection of the mortality in Cheshire and Lancashire with the price of corn is exemplified by the following abstract:—

	Price of Wheat.	Deaths in 100,000.	
		Males.	Fem.
1838, { 1st six mo., 58/ 2d six mo., 70/ }	64/7	2697	2439
1839, ...	70/8	2960	2727
1840, ...	66/4	3069	2846
1841, ...	64/4	2638	2445

It is a rare thing for a hard-working artisan to arrive at a good old age; almost all become prematurely old, and die long before the natural term of life. Hence it is, that, as Dr Southwood Smith has remarked, the mortality of a country may be considered as an accurate indication of the misery of its inhabitants. According to Villermé, the rate of mortality among the poor is sometimes double that among the rich. Thus, it is found, he says, that in a poor district in France one hundred die, while in a rich department only fifty are carried off; and that, taking into account the whole population of France, a child born to parents in easy circumstances has the chance of living forty-two and a half years, while one born of poor parents can look for no more than thirty.*

These are striking facts, and their truth is amply confirmed by the Registrar-General's Reports. It appears, for instance, that while the deaths in a population of 273,000, occupying the seven Welsh districts, amounted in the third quarter of 1846 to 1465, they reached the fearfully greater number of 3149 among the 263,000 inhabitants of Manchester and Salford. (Ninth Annual Report, p. xxiii.) In the same Report, the Registrar says: "The population of Surrey exceeded that of Manchester; yet in seven years (1838-44), 16,000 persons died in Manchester over and above the deaths in Surrey, the mortality in which, from the poverty of the labourer, and slighter degrees of the influences so fatal in Manchester, is higher than it should be. There were 23,523 children under 5 years of age in Surrey, and the deaths of children of that age were 7364; the children in Manchester were 21,152, the deaths 20,726. In the 7 years, 13,362 children in Manchester alone fell a sacrifice to known causes, which, it is believed, may be removed to a great extent; and the victims in Liverpool were not less numerous." (P. xxiv.) Many causes, no doubt, concur to produce these melancholy results; but among the principal must be placed the want of a diet sufficiently nutritious to repair the waste of the system, and, in the young, to supply the materials for growth. By the Registrar of Deansgate, Manchester, the frightful mortality of the children is traced, in a great measure, to the "unfortunate out-door occupation of the women, which, by causing the withholding of nature's nutriment from the children, is terribly destructive to the latter." In the army, the operation of the same principle has long been recognised, in the inferior strength and health of the privates compared with the officers. The officers, being better fed, clothed, and lodged than the common soldiers, bear up successfully against fatigue and temporary privations by which the latter are overwhelmed. During epidemics, too, the poor, from their impaired stamina, almost invariably become victims in a proportion far exceeding that of the more wealthy classes. This is, no doubt, partly owing to their greater intemperance and want of cleanliness; but even these vices often derive their origin from the same root—the want of adequate repose and sustenance.

Nowhere, however, have the lamentable consequences of an insufficiency of wholesome food been exhibited on a larger and more destructive scale, and nowhere, perhaps, did the sufferings caused by it attract less of public attention and sympathy, than in the Royal Navy prior to the end of the last century. Every one has heard of the alarming mutiny of the fleet at Spithead, followed by that at the Nore,

* Smith's Philosophy of Health, chap. iv.

in the spring of 1797; but it is not so generally known that *habitual semi-starvation*, arising from the bad quality and deficient quantity of the provisions, was one of the chief causes of that mutiny. Such, however, is the fact. At the time, indeed, the allegation was denounced as utterly without foundation, and as purely the offspring of a rebellious spirit; but its literal truth is now not only admitted, but placed officially on the public records of the country; and the lesson which it conveys is full of instruction to every one who is capable of serious reflection, and takes an interest in the happiness of his fellow-creatures.

For ample proof of the reality of the grievances complained of in the navy before the mutiny of 1797, I need only refer to the "Statistical Report of the Health of the Navy for the year 1830 to 1836 inclusive," published a few years ago by order of the House of Commons. At that time, says the Report, the system of victualling and management prevalent in the navy was such, that "a ship of war was, on many accounts, an object of aversion; destructive disease, under various forms, being one. Scurvy, putrid ulcer, malignant dysentery, and fever allied to that of gaols, suddenly *swept off the greater portions of many ships' crews, and wellnigh depopulated fleets.* Many causes, no doubt, concurred to occasion those maladies; but *in the production of the first and worst, the most fertile and constant (cause) was* INSUFFICIENT NUTRITION, RESULTING FROM SCANTY AND INSUFFICIENT FOOD.

Of the perfect truth of this latter statement even the most sceptical will be convinced, when it is added that the rations then furnished not only were often of bad quality, but *did not exceed two-thirds of the quantity now ascertained to be requisite for human sustenance.* At that time "the nutriment supplied by public rations to seamen and marines was at least *one-third less* than it is now. It is abundant, but not in excess, at present; it is, therefore, not wonderful, however deplorable," continues the Reporter, "that the insufficient supplies of those days, without any strong concurring agency, should occasion diseases of absolute debility, or excite disease by it, leading to so much misery and death. The necessary evils of war, whether arising from battle or shipwreck, WERE TRIVIAL WHEN COMPARED WITH THOSE TREMENDOUS CALAMITIES WHICH MIGHT HAVE BEEN AVOIDED." (P. xiii.)

These extracts, borne out as they are by other evidence, afford ground for deep and solemn reflection, and place the value of physiological knowledge in a very striking light. In 1772-5, or more than twenty years before the mutiny, Captain Cook, by a more liberal system of victualling, and greater attention to the ordinary conditions of health, had carried his crews uninjured through all the hardships and vicissitudes of climate incidental to an arduous voyage of nearly three years' duration; and had thus *demonstrated* that the sickness and mortality prevalent in the navy were *not* necessary evils, but were, in truth, easily avoidable by the exercise of a little prudence and skill, and by the better observance of a few of the simplest laws of physiology. Such, however, was the apathy engendered by professional ignorance and official routine, that, with this palpable and most instructive example before their eyes, and with the full detail of the means so successfully resorted to by Captain Cook, accessible to every one in his published Narrative, "the depopulation of fleets," and other "tremendous calamities," compared with which the evils of warfare and shipwreck were "trivial," were allowed to go on from year to year without any efficient means being used to prevent them, till the sufferers at last were compelled by their misery to insist upon redress at the price of rebellion! With much reason, then, does the Reporter say, that "had the lessons which Cook's conduct taught in regard to the provisioning and economy of ships been properly learned and acted on, much subsequent misery and loss might have been avoided in the navy."

That the seamen engaged in the

mutiny had ample grounds for dissatisfaction and complaint, is still farther demonstrated by the results which followed the redress of their grievances. "In 1797," says the Report, "the victualling was changed, greatly improved, and strictly regulated; and CONSEQUENT IMMEDIATELY TO THE CHANGE, THE HEALTH OF SEAMEN IMPROVED STRIKINGLY. Scurvy, typhoid fever, dysentery, and ulcer, which, up to the period of the change, had produced great havoc, became comparatively rare in occurrence and light in impression." *At the present day*, these four forms of disease, once so destructive, and which "would appear at one time to have been considered evils in some way inherent in a sea life, . . . are proved to be no more dependent on residence in a ship than in a house, and ARE SCARCELY KNOWN EXCEPT BY NAME." (P. xiii.)

Here, then, we have a picture which may well startle the blindest follower of routine, or the most ardent worshipper of things as they are. It cannot for a moment be believed that the Navy Board intentionally and deliberately inflicted these enormous calamities on the fleets entrusted to their care. Had the official authorities been aware of the true causes of the sickness and destructive mortality on shipboard, and of the facility with which those evils could be obviated, considerations of economy alone, not to speak of motives of justice, humanity, or patriotism, would have induced them to make that provision for the comfort and health of the seamen which IGNORANCE alone withheld, at not less peril to the country than injury to the sufferers. But, in those days, few professional and still fewer official men, ever turned their attention to the conditions required for the preservation of health, or imagined that a general acquaintance with the physiology of the human body could be turned to any useful account in securing the health, comfort, and efficiency, of either themselves or others. Hence, it was left to the suffering seamen to be the first to insist on the removal of the evils to which they were so long and so needlessly exposed. Even in civil life, it is painful to think how much avoidable suffering still continues to be incurred from the same deplorable ignorance and apathy; and I cannot but rejoice in the clear and enlightened views on this very subject, so ably and earnestly expounded in Mr Chadwick's admirable "Report to the Poor-Law Commissioners on the Sanitary condition of the Labouring Population of Great Britain," and in the more recent "Report of the Commissioners for inquiring into the State of large Towns and Populous Districts;"—reports which have already been followed by most useful legislative enactments, and must ultimately become as prolific of reforms in social life, as the mutiny at the Nore was unquestionably corrective of many of the sources of suffering and disease prevalent in ships of war.

As, however, I have spoken freely of the abuses formerly prevalent in the navy, justice requires me to add, that of late years the naval service has been pre-eminently distinguished for the liberality, judiciousness, and efficiency of its arrangements for the comfort, health, and general improvement of those employed in it. It is, indeed, in the highest degree creditable to the medical officers of the navy, that, with equal or even greater disadvantages of education than their brethren in civil life, they are now decidedly in advance of them in their attention to the means of preserving health and promoting human enjoyment; and the results which they have achieved are such as to excite surprise and admiration. Of the truth of these statements we have most convincing and gratifying proofs, not only in the various expeditions of discovery to the northern and southern regions, which have left the shores of Britain within the last forty years, and returned almost without the loss of a man by disease; but still more in the high average health and comfort now enjoyed in all our fleets, and in ships on every kind of duty, and in every variety of climate. The rate of mortality is now so low, that in the seven years, 1830-36,

it amounted to only 13·8 per 1000 for the whole fleet, including the vessels on the most unhealthy stations. Even off the western coast of Africa, the crews remain healthy so long as the ship keeps the open sea; and suffer from fever only when obliged, in discharge of their duties, to come within the sphere of the pestilential vapours of the rivers and seaboard. Indeed, a more encouraging incentive to future exertion can scarcely be conceived, than the contrast between the state of health in the navy sixty years ago and at the present time.

But it is not the bodies only of the labouring and poorer classes which are injured by a deficiency of wholesome nourishment. *Their minds also are deteriorated.* The pressure of poverty is unfavourable to the growth of refinement and morality, and crime and turbulence are never so much to be dreaded as during times of scarcity, and manufacturing or agricultural distress. Bodily health, satisfied appetite, and peace of mind, are great promoters of individual morality and public tranquillity; and whenever these are encroached upon in any great class of the community, discontent and crime are sure to follow. Some very impressive evidence of the connexion of bodily welfare with morality and intelligence was published a few years ago in the "Report of the Commissioners for inquiring into the State of large Towns," and the "Report of the Commissioners on the Poor-Laws of Scotland." The evidence of Dr Southwood Smith (appended to the former) on the mental apathy and degradation of the wretched beings huddled together in filthy and ill-aired recesses of large towns, is particularly striking.*

Coupling such testimony with the rare occurrence of crime among those who enjoy the comforts of life, it will scarcely be denied that, in legislation, the principle here inculcated is far too little attended to, and that, consequently, laws are enacted merely for the suppression of *the result*, while its *cause* is disregarded, and left in full operation.

Among the poorer classes, the children as well as the parents suffer much, both physically and morally, from insufficient food. Their diet, being chiefly of a vegetable nature, and consisting of a scanty allowance of porridge, potatoes, and soups, with very little butcher-meat, is far from adequate to carry on vigorous growth in the young, or repair waste in the adults: hence arise in the former an imperfect development of the body, a corresponding deficiency of mental power, and a diminished capability of resisting the causes of disease. In workhouses and other charitable institutions, ample evidence of these deficiencies obtrudes itself upon our notice, in the weak and stunted forms and very moderate capacities of the children. Under an impoverished diet, indeed, the moral and intellectual capacity is deteriorated as certainly as the bodily; and a full exposition of this fact, and of the principles involved in it, would be a great public benefit.

As tending to enforce these remarks, I may mention, that when Sir John Franklin and his companions were reduced to a state of starvation at Fort Enterprise, in November 1821, he was struck with the signs of weakness of intellect which they exhibited: "I observed," says he, "that as our strength decayed our minds exhibited symptoms of weakness, evinced by a kind of unreasonable pettishness with each other. Each of us thought the

* Abundant proof of the influence of starvation in leading to crime, may be found in Dr Alison's excellent "Remarks on the Report of Her Majesty's Commissioners on the Poor-Laws of Scotland." In his previously-published work, "On the Management of the Poor in Scotland," he says—"The effect of extreme destitution on the general conduct of man is *brutalizing*,—it is to deaden, more or less, the sensibility to all feelings of a higher order than the sensual appetites."—(P. 117.)

The acts of incendiarism which abounded in Suffolk in 1844, afford a very striking illustration of the demoralizing effects of want. From the evidence collected by a gentleman sent down to that county by the proprietors of the *Times*, it appears that the crime referred to prevailed chiefly in consequence of the misery arising from insufficiency of employment, and was hardly known in those districts where the labourers could earn even a bare subsistence. "The clergyman of the next village," says the reporter, "told me,—'The labourers' wives, when I called at their cottages, tell me, 'My husband has been out of work three days or two days this week, and we and the children are almost hungered: it's hard to bear, God knows: *and it puts bad thoughts into my husband's head.*'" This clergyman told me he had heard these fearful words, 'It puts bad thoughts into my husband's head,' fifty times."

other weaker in intellect than himself, and more in need of advice and assistance. So trifling a circumstance as a change of place, recommended as being warmer and more comfortable, and refused by the other from dread of motion, frequently called forth fretful expressions, which were no sooner uttered than atoned for, to be repeated perhaps in the course of a few minutes. The same thing often occurred when we endeavoured to assist each other in carrying wood to the fire; none of us were willing to receive assistance, although the task was disproportioned to our strength. On one of these occasions, Hepburn was so convinced of this waywardness, that he exclaimed, 'Dear me, if we are spared to return to England, I wonder if we shall recover our understandings.'"* This narrative affords a striking confirmation of the truth, that unless the brain be adequately nourished and stimulated by the blood, the mental faculties cannot display that energy which characterises them in opposite circumstances.

I must here add, that want of appetite in ill-fed persons is by no means a correct indication, as in the healthy state, that the supply of food is sufficient for the wants of the system. This fact is well illustrated by the recent experiments of Dr Chossat, to determine the result of inadequate alimentation.† "A number of turtle-doves were supplied with limited quantities of corn, but with water at discretion; and two very interesting results presented themselves. In the first place, the amount of loss was almost exactly the same as in the case of complete abstinence, but life was prolonged for about double the length of time. Secondly, *it appeared that in scarcely any instance was the whole amount of food that the birds were allowed to take actually digested;* a part of it being rejected by vomiting, or passing off by diarrhœa, or accumulating in the crops. It seems that the vital power was not sufficient to furnish the requisite supply of gastric juice, when the body began to be enfeebled by insufficient nutrition; or, perhaps we might well say, the materials of the gastric fluid were wanting. We need scarcely point out," adds the writer from whom I borrow these particulars,* "the very important practical applications of this principle. The loathing of food often manifested by those who have been subjected to the influence of an insufficient diet-scale in our prisons and poorhouses, has been unjustly set down to caprice or obstinacy, and punished accordingly; whereas it is actually a proof of the deficiency of the supply, which, it might be imagined, would have been voraciously devoured if this were really the case." This opinion is corroborated by the experiments which were made upon himself by Dr Stark, a physician of the last century. Dr Stark found that, after living some time on bread and water with sugar, he was forced to discontinue this diet by the loathing it occasioned, while its effects upon the system were so injurious as to produce a severe attack of scurvy. At another time, when much weakened by the prolonged use of a low diet, he observed, on returning to the use of animal food, that pieces of the beef passed through his bowels undigested.†

Even among the children of the wealthier classes, a sufficiency of nourishing food is not always provided. In families as well as boarding-schools, it is too common to stint the healthy appetites of the young, or to feed them with soups and other eatables which contain too little nutriment in proporportion to their bulk. I am acquainted with many instances of this most injudicious error, and have seen scrofula and severe digestive affections brought on by persevering in it, through sheer ignorance, and even in the belief that such "temperance" was healthful. Where adequate exercise is permitted, and the food is plain and nourishing, hurtful excess in eating will rarely occur, at least in healthy children.

* Journey to the Polar Seas, vol. i., p. 466.
† Recherches Experimentales sur l'Inanition, par Charles Chossat, M.D. Paris, 1843.

* Brit. and For. Med. Review, xvii. 348.
† The Works of William Stark, M.D. London, 1788

CHAPTER XI.

CONDITIONS TO BE OBSERVED BEFORE AND AFTER EATING.

General laws of organic activity apply to the stomach as well as to other parts—Increased flow of blood towards the stomach during digestion—Effect of the fulness of the stomach upon other organs—Causes of diminished aptitude for mental and bodily exertion immediately after meals—Rest and tranquillity essential to sound digestion—Rest always attended to before feeding horses—Natural aversion to exertion immediately after eating—Mischief done by hurrying away to business after meals—Length of the repose necessary—Influence of the nervous system on digestion—Dr Reid's experiments considered—Intense thinking hurtful after meals—Playful cheerfulness conducive to digestion—The mind often the cause of indigestion—Also influences nutrition—Illustration from Shakspeare—Importance of attending to this condition of health enforced.

HAVING now discussed the principles by which the number and quantity of our meals ought to be regulated, we have next to consider the conditions required for the healthy performance of digestion after the aliment has reached the stomach, and to deduce from them such practical rules as shall tend to facilitate the accomplishment of the process.

Among the circumstances which favour digestion, the observance of bodily rest and mental tranquillity for some time before and after every meal, is perhaps the most important; its influence depends on a well-known law of the animal economy, already frequently alluded to, but to which, that it may be well understood, I must again solicit the reader's attention.

Whenever any living part is called into vivid action, an increased flow of blood and of nervous energy towards it immediately commences, to enable it to sustain the requisite degree of excitement, and continues till some time after the activity has ceased. In accordance with this law, whenever food is swallowed, the lining membrane of the stomach becomes suffused with blood, and, owing to the greater distention of its vessels, its colour changes from a pale pink to a deep red hue. After digestion is completed, and the unusual supply of blood is no longer required, the vessels again diminish and the colour returns to its original tint. In St Martin's stomach, these changes were so often seen by Dr Beaumont, as to render their occurrence as fully demonstrated as any fact with which we are acquainted. Even had they never been seen, the simple examination of the structure of the stomach would lead us directly to the inference that it receives an additional supply of blood when engaged in digestion; for the very act of its distention by food renders the course of its bloodvessels less tortuous, and the flow of blood through them consequently more easy and rapid. In the case of the stomach, indeed, the increased circulation is doubly required; not only, as in other parts, to enable it to act with greater muscular vigour, but also to supply the very copious secretion of gastric and mucous fluids necessary for digestion—a secretion which we have seen to commence the moment food touches the mucous coat. The quantity of gastric juice secreted at each meal cannot easily be determined; but as more than an equal weight of it is required for the solution of food out of the stomach, its amount must be very considerable. Indeed we know that, on one occasion when St Martin dined on broiled mutton and bread without any liquids, the gastric secretion was so copious, that half an hour afterwards "the stomach was as full of fluids as when he drank a pint immediately after eating;"* and, as the whole of this must have been derived from the blood circulating through the vessels of the stomach, they must have received a very large supply of blood to enable them to furnish it.

It is obvious, however, that the great afflux of blood which takes place towards the stomach and intestines during digestion, cannot occur without a corresponding diminution of the quantity circulating on the surface and in other distant parts of the body, attended, of course, with a diminished power of action in them. Hence, in delicate persons, a degree of coldness or chill is often felt over the whole body. During vigorous health, how-

* Beaumont's Experiments and Observations on Digestion, &c., p. 185.

ever, this chilliness does not occur, or is limited to the lower extremities. When a copious meal has been taken, the distended stomach presses upon the descending aorta (the large artery which supplies the trunk and lower extremities), and thus impedes to some extent the downward current of the blood. As a natural consequence, the supply of blood to the head is increased, producing a degree of pressure on the brain; and the countenance, especially in the case of persons who eat largely, becomes red and suffused. Owing to the diminished action of the diaphragm or midriff—another consequence of the distended state of the stomach—the lungs do not receive their full supply of air, and the blood is less perfectly oxygenated. If, to these two causes, we add the concentration of the nervous energy upon the process of digestion, we shall see abundant reason why, for some time after a full meal, there is but little aptitude for vigorous thinking and bodily exertion, and why, in extreme cases, this condition passes into apoplexy, especially when the heart has been stimulated to powerful action by the free use of wine or other alcoholic liquors. As digestion proceeds, the contents of the stomach diminish, and the pressure on the aorta is gradually lessened; respiration becomes free, and the blood is again equally distributed through the body. The stimulus of the digested aliment gently excites the various organs, and the system becomes fit for the active resumption of the duties of life.

That this impaired activity of some of the functions after a full meal is natural, and intentionally arranged by the Creator, is plain, both from its universality among all kinds of animals, and from the mode in which it is produced. Among the lower creatures, the sluggishness induced by eating increases in proportion to the degree in which they gorge themselves with food. After a plentiful repast, the boa constrictor slumbers for a week, and the glutton of our own species drops into a stertorous sleep of several hours. If active exertion immediately after a full meal be rendered compulsory by any external cause, such as the presence of danger urging to flight, the aliment often remains for hours in the stomach undigested.

The obvious practical inference to be deduced from a consideration of the principle under discussion is, that rest of body and tranquillity of mind for a short time both *before* and *after* eating are necessary, and conducive to healthy digestion. If we have been engaged in severe and fatiguing bodily exertion just before sitting down to a meal, digestion is impaired in two ways; and it would be well for dyspeptics to attend to the fact. The stomach itself participates in the general weakness caused by the bodily fatigue: and, in the next place, the blood, which was flowing copiously through the vessels of the muscles to keep up their unusual action, still continues to do so, because a sufficient interval has not elapsed to allow the excitement to subside, and a new distribution to take place towards the organs concerned in digestion. The consequence is, that the stomach does not receive blood enough to carry on its increased action, and furnish gastric juice with sufficient rapidity or in the requisite quantity; and that the nervous energy, already partially exhausted by over-excitement in the remoter organs, is imperfectly supplied to the stomach, the tone and action of which are thus so far impaired as to render it no longer able to carry on digestion with its usual success. Nearly the same result ensues when we have been engaged in anxious thought or study just before eating; and, accordingly, when we are fatigued with mental or bodily labour, we are naturally impelled to seek repose before sitting down to table. If we yield to this instinctive prompting, and refresh ourselves by a rest, we not only enjoy better what we eat, but also digest it with an ease and comfort unattainable if we swallow our food the moment our labour is at an end—and hence the wisdom and advantage of appropriating half an hour to any light occupation, such as dressing, before sitting down to dinner. If, how-

ever, we have previously been engaged only in very moderate exercise, or amusing reading, an interval of repose is not required, because then there is no undue excitement elsewhere to retard the necessary flow of blood and nervous energy towards the internal organs.

The practical rule of avoiding serious exertion of mind or body immediately *after* eating, which is directly deducible from the physiological law above explained, has long been acted upon in our treatment of the lower animals; and no one who sets any value on the lives of his horses or dogs, ever allows it to be disregarded with respect to them. And yet the same man who would unhesitatingly dismiss his groom for feeding his horse immediately after a fatiguing chase or a gallop home, would probably think nothing of walking into the house and ordering dinner to be instantly served for himself in similar circumstances. In the army, the difficulty of managing recruits on a march, in this respect, has often been remarked. Fatigued with the day's exertions, they are impatient for food, and, when they get it, scarcely can refrain so long from devouring it as to admit of its being even moderately cooked. They consequently labour under the double disadvantage of eating before the system is in a sufficient state of repose to benefit by the supply, and of having the food itself in a condition unfit for easy digestion. The old campaigner, on the other hand, instructed by former experience, restrains his appetite, systematically kindles his fire, cooks his victuals, and makes his arrangements for the night with a coolness and deliberation which surprise the recruit; and he is amply repaid for his temporary self-denial, by the greater enjoyment and support which he derives from the very same materials which the impatience of the other has caused him in a great measure to waste.

Let any one who doubts the advantages flowing from attention to this rule, consider for a moment its universal and scrupulous observance by postmasters and jockeys, and think whether these are persons likely to throw away time and trouble on a useless ceremony. When a horse is taken out of harness, an interval of repose is always allowed, that the excitement of the system may have time to subside; and then not only an eager appetite but an active digestion is sure to follow. Many a valuable horse has been killed by being prematurely fed after fatiguing exercise; and man himself is no exception to the rule. He not only enjoys a meal with superior relish, but digests it better, when due repose has removed the fatigue and excitement of exertion. Even after continued activity of *mind*, a period of tranquillity or of gentle bodily exercise is eminently conducive to the healthy action of the stomach, precisely because it favours the new distribution of the blood and nervous energy which digestion requires.

In accordance with this law of digestion, there is throughout the whole animal creation a marked aversion to activity for some time after a full meal; although man, eager in the pursuit of gain or the gratification of other passions, often sets it at defiance, and engages in bodily or mental labour both immediately before and after meals. But, in return, he receives his reward for despising the authority of Nature, in a severity of suffering from which the animals which he treats so much better than himself are by his care entirely exempted. Nowhere, for example, do men hurry off to business so immediately as in the United States of America, and nowhere do they bolt their food so much, as if running a race against time. The consequence is, that nowhere do intemperate eating and dyspepsia prevail to the same enormous amount. Even in England, according to Dr Caldwell, the extent of transgression cannot be compared with what is witnessed among our Transatlantic brethren; and the result shews, that if we in Britain suffer from indulging our fondness for good things, the comparatively deliberate way in which we set about enjoying them serves as a partial safeguard, and ex-

empts us from a portion of the punishment which the Americans bring down upon themselves. Rapid eating almost invariably leads to overloading the stomach; and when to this is added a total disregard of the quietude necessary for digestion, what can be expected to follow but inveterate dyspepsia? Nowhere, accordingly, are indigestion and its consequences so generally met with as in the United States; and the evil seems to be rather increasing than abating.

As illustrative of the above remarks, and as tending to enforce the rules laid down, by shewing the consequences of their neglect, we quote the following instructive case from M. Levy's *Traité d'Hygiène* (vol. ii., p. 451):—A soldier of the Municipal Guard of Paris, after several hours' march, entered his quarters about eight o'clock in the evening, and, without waiting to rest, hurriedly devoured a copious meal of mutton, potatoes, French beans, and prunes, finishing with a large draught of water. He immediately put himself *en route* for his post, three-quarters of a league distant, and had scarcely reached it when he was attacked with severe griping and vomiting. He was removed to his quarters, where he passed the night in great pain, and on the following morning was conveyed to the hospital of Val-de-Grace. Here, under the care of M. Levy, his sufferings continued unabated till the noon of the following day, when he died. On examining the body, the stomach was found empty, and its mucous membrane pale and bloodless. The upper part of the small intestines was also unnaturally pale and deprived of blood, but it contained a large quantity of undigested food, consisting of pieces of meat, fragments of potato, beans, and the skins of prunes. At their lower part, the small intestines were strangulated, and the passage completely closed.—Here we find a copious meal introduced into the stomach at a time when its nervous energy was exhausted by fasting and severe exercise, and when its blood-vessels were empty in consequence of the flow being directed upon the muscles. No time was given to the system to recover tone, or to allow the secretion of gastric juice to take place. On the contrary, the exercise was immediately resumed; and the food, from not being digested, acted as an irritant, stimulating the muscular coat to violent contraction. Vomiting and colic were thus excited, followed finally by such excessive action of the small intestines as to produce strangulation of the bowels, and consequent death.

The reason why wounds, bloodletting, bathing, and other circumstances which tend to disturb the regularity of the circulation, are so hurtful after a full meal, will now be apparent. The effect of wounds and bloodletting is an instantaneous change in the distribution of the blood, depriving the stomach of that which is now doubly required. Bathing, whether hot or cold, has an analogous effect; and so, indeed, have all violent and sudden bodily or mental shocks.

It must not, however, be imagined that the period of repose necessary to ensure healthy digestion extends over the whole time of the continuance of food in the stomach. After a moderate meal, and in ordinary health, the concentration of the vital powers in that organ, and their proportionate depresssion in other parts of the body, rarely continue, at least in a very marked degree, beyond the period usually allotted to the *siesta*, or sleep after dinner, in warm climates and even in Italy and Spain—namely, an hour or an hour and a half. When the meal has not exceeded the bounds of moderation, *a sufficient quantity of gastric juice for the digestion of the whole is secreted generally within the first hour;* after which time, consequently, the same amount of blood and nervous energy is no longer required to be directed towards the stomach, but may beneficially be distributed to such other parts as, from their activity, more immediately require its aid. If the muscular system is to be employed in labour or locomotion, they can now be spared to sustain its activity; if the mind is to be engaged in intellectual pursuits, the brain can now be called into vigorous action without detri-

ment to digestion. The same principle of course applies to all the other organs; and it is therefore chiefly during the first hour, till all the gastric juice be provided, and the chymification of the food be fairly commenced, that tranquillity of mind and freedom from exertion of body are needful.

As already mentioned, the reality of increased circulation in the vessels of the stomach during digestion has been established by ocular observation, as well as by analogy. The increase in the supply of nervous energy which takes place at the same time is, however, scarcely less certain, although, from its nature, incapable of being seen. It is the almost characteristic feature of the nervous system to be excited by stimulus to increased action; and, on the other hand, we find that when, by section of the nerves, the stimulus of the food is prevented from passing from the stomach to the brain, and the nervous energy from being transmitted from the brain to the stomach, digestion is immediately arrested. In illustration of this fact, the following experiment by Bernard de Villefranche is peculiarly apposite. This physiologist produced a fistulous opening into the stomach of a dog, and after the animal had recovered from the effects of the operation, he kept it without food for twenty-four hours. On the mucous membrane being then stimulated, by the application of a sponge introduced through the opening, it was observed to become immediately red and turgid, and the gastric juice was secreted in considerable quantity. The pneumogastric nerves were now cut on both sides, in the middle region of the neck, and the mucous coat immediately lost its turgidity, and became pale and bloodless. The sensibility and motion of the stomach were destroyed, the flow of gastric juice was arrested, and muscular fibre introduced into the stomach did not undergo the slightest change.*

It is proper here to observe, that the dependence of digestion on the nervous system has lately been called in question by a writer in the British and and Foreign Medico-Chirurgical Review. In the Number for January 1849 (vol. iii., p. 104), the reviewer of Dr Robertson's work on Diet and Regimen, says: "The assertion by this author, that 'the peptic functions of the stomach require for their performance a large amount of vital or nervous power,' appears to us gratuitous, although we are aware that it is in accordance with current belief. But since the experiments of Dr John Reid have shewn that the digestive process will go on pretty nearly or quite as well *after* section of the par vagum (the pneumogastric nerve) as *before*, when the first shock of the operation has passed away, we cannot see how it can be any longer sustained upon a valid foundation." This is virtually denying the influence of the nervous system upon digestion, and it is therefore important to ascertain upon what foundation the writer rests so startling a doctrine. Dr Reid's own statement on the subject is this: "That lesion of the *vagi* (pneumogastric nerves) is generally followed by vomiting (in those animals susceptible of it), loathing of food, and arrestment of the digestive process, has been incontrovertibly proved by numerous experimenters. That perfect digestion may occasionally take place after division of the vagi in the neck, even when the cut ends of the nerves are kept apart from each other, we are fully convinced. In four of the seventeen animals experimented upon for the purpose of examining the morbid changes in the lungs, we obtained sufficient evidence of the restoration of the digestive process."*

We cannot, in a work like this, enter fully into the details of these four experiments; but a few remarks will suffice. There of the four dogs died in consequence of the operation, at the end of periods varying from seven to eleven days. During the first three or four days, the food which they took was for the most part vomited unchanged, and at a later period was still very gene-

* Comptes Rendus de l'Academie, 1844, p. 995.

* Pathological and Anatomical Researches by John Reid, M.D. Edinburgh, 1848. P. 222.

rally vomited, and only slightly altered. The animal food was softened on the surface, and very partially converted into acid chyme. The proof of digestion, found after death, was the presence of chyle in the lacteals and thoracic duct.

The subject of the fourth experiment, on which the greatest stress is laid, was operated upon on the 15th of June, and was poisoned by prussic acid on the 27th. Up to the 23d, the greater portion of the food taken was vomited unchanged; but on that day, the ejected animal food "was partly in a pulpy state, but without fetor." On the 24th and 25th, there was still vomiting of partially-digested food. On the 26th, the animal ate largely of animal food without vomiting, and on the 27th, being very active and lively, it received three-quarters of a pound of sweet butter, part of which it immediately vomited, and again swallowed. Four hours afterwards it was poisoned. Part of the butter, altered in its appearance, was found in the stomach and small intestines, and the lacteals and thoracic duct were filled with a white milky fluid.

In weighing the value of this experiment, it is important to bear in mind that the digestion of fat is not dependent on the gastric juice, and that, consequently, the presence of a creamy fluid in the lacteals is not evidence of gastric digestion having taken place. It is much to be regretted that the animal should have been poisoned at so early a period, as the time that elapsed was too short to prove that digestion was thoroughly re-established, and that the animal could continue to live. But granting most fully all the deductions that can be legitimately drawn from Dr Reid's experiments, we can allow nothing beyond what is already stated at page 10, namely, that the pneumogastric nerves are not the sole conductors of nervous energy to the stomach. We cannot admit, with the reviewer, "that the digestive process will go on pretty nearly or quite as well *after* section of the par vagum as *before*." Dr Reid himself says: "It is of importance to remark, that we only obtained distinct evidence of digestion in the four animals which lived beyond the fifth day, and that even in these the digestive process was at first completely arrested, and only gradually improved. In the other thirteen experiments, the animals either refused to take food, or the food when taken was either vomited or remained in the stomach unchanged. We believe, then, that we are justified in concluding, that a deleterious influence is propagated downwards to the stomach by a lesion of the *vagi*; yet, that if the animal live for a certain time, the digestive process may be re-established."—(P. 229.) The conclusion to be drawn may, in our opinion, be more correctly expressed by saying, that the section of the nerves prevents the propagation of a *beneficial* influence from the brain to the stomach; in other words, that the flow of nervous energy is cut off.

But the same principle holds in the nervous as in the circulating system—energetic action cannot be kept up in two distinct and distant parts of the body at the same time. If the intellect be intently occupied in profound and absorbing thought, the nervous energy will be concentrated in the brain, and any demands made on it by the stomach or muscles will be very imperfectly attended to. If, on the other hand, the stomach be actively engaged in digesting a full meal, and some subject of thought be then presented to the mind, considerable difficulty will be felt in pursuing it, and, most probably, both thought and digestion will be disturbed. If the mental effort required be easy and agreeable, and the meal be a very temperate one, there will be much less difficulty in simultaneously proceeding with both, because comparatively little nervous energy will then suffice for them. Still, however, each will go on more efficiently if not interfered with by the other. We have a familiar instance of the effect of mental occupation or uneasiness in checking secretion, in the test which is applied in India to the detection of a thief, namely, causing the suspected culprit to chew a quantity of dry rice.

His guilt is supposed to be proved if the salivary glands refuse their office. In like manner, we find Goldsmith making the following confession of his feelings at a supper which took place after the first representation of "The Good-Natured Man," the success of which piece had been doubtful. "All the while," he says, "I was suffering horrid tortures, and verily believe, that if I had put a bit into my mouth, it would have strangled me on the spot, I was so excessively ill; but I made more noise than usual to cover all that, and so they never perceived my not eating, nor, I believe, at all imaged to themselves the anguish of my heart."*

When the mind is active and vigorous, and properly exercised in all its departments of feeling and affection, as well as of intellect, the nervous influence which the brain produces is not only more abundant, but of a more healthful and invigorating quality. Hence the well-known preservative and restorative influence of cheerful dispositions and gratified activity of mind; and hence the depressing, morbific, and often fatal effects of corroding care, grief, and apprehension, on every organ of the body. Hence, too, the weak digestion and sallow complexions of literary men and hard students, who suffer severely from disregarding this law of the animal economy, by habitually engaging in occupations requiring much exertion of mind, not only soon after, but even during the very act of swallowing their meals. In this way many delicate persons suffer from the peculiarly English practice of reading the newspaper during breakfast. Ignorant of the connection existing between the different functions, and of the laws of their action, such persons cannot be convinced in time of the mischief they are doing, even after its operation has been explained to them. In the end, however, experience teaches many whose reason is insufficient for their guidance, and forces them to act in conformity with the dictates of Nature, when obedience is almost too late to be of benefit.

The important influence of the nervous system on digestion is familiarly and unequivocally exhibited in almost every case of dyspepsia which each succeeding day brings under the notice of the physician. *He* knows well, from experience, that the diet may be selected with every care, its quantity duly regulated, and exercise rigidly practised, and yet all his curative treatment fail even to relieve, unless his patient be at the same time freed from the pressure of care, and due attention be devoted to the observance of mental and bodily repose after every meal.*

The heavier the meal, the greater is the desire for absolute rest, and with the less likelihood of avoiding injury can active exertion be encountered. When the stomach is loaded, the whole vital energies seem to be concentrated in it, to enable it to perform its task. But when we eat temperately, there is less necessity for entire quietude of mind and body; and, accordingly, we do not experience the same dislike to exertion after a light forenoon lunch, as after a heavy late dinner. The chief reasons are, that less blood and gastric juice, less nervous energy, and less vigorous action in the stomach, are required to digest in the one case than in the other; and that the blood continues to be more equally distributed to the brain and other organs.

Among operative manufacturers who are much within doors, and who are allowed only a few minutes for meals, indigestion is very prevalent. Ordinary labourers are better treated in this respect, as they are allowed one hour for breakfast and another for dinner. To most of them the walk to and from their own houses is almost as good as absolute rest, if not better, be-

* Forster's Life of Goldsmith, p. 461.

* Much useful information concerning the influence of mental states upon the health, will be found in a recent work, entitled, "Mental Hygiene; or an Examination of the Intellect and Passions, designed to illustrate their Influence on Health and the Duration of Life. By William Sweetser, M.D., late Professor of the Theory and Practice of Physic, and Fellow of the American Academy of Arts and Sciences." It has been reprinted in a cheap form for Maclachlan, Stewart, and Co., Edinburgh; and Simpkin, Marshall, and Co., London. 1844.

cause it varies their position, is taken leisurely, and costs no effort.

Those whom circumstances compel to active exertion immediately after a meal, or whose minds are intently occupied in thought or emotion, will find their only safety in eating less than when differently situated. The stomach, having less labour imposed upon it, will require less blood and less nervous energy, and consequently less of both will be abstracted from the other organs which are also in activity, and requiring their assistance. Travellers, literati, and other actively engaged men, know this rule by experience, and some of them have specially noticed its importance. Richard Cumberland, for example, in speaking of his own habits, says: "Nature has given me the hereditary blessing of a constitutional and habitual temperance, that revolts against excess of any sort, and never suffers appetite to load the frame. I am, accordingly, as fit to resume my book or my pen the instant after my meal, as I was in the freshest hours of the morning."* This compatibility of temperate eating with activity did not escape the acute observation of Hippocrates.

The state of the mind, indeed, exerts a powerful influence, not only on the stomach, but on the whole process of nutrition, and greatly modifies the quantity which may be safely eaten. If the mind be gay and joyous, appetite will be comparatively keen, digestion effective and rapid, and nutrition complete. Examples of this kind abound in childhood, and among an easy-minded well-fed peasantry; whereas, if the mind be harassed by care and anxiety, or devoured by grief, envy, jealousy, or other troublesome and disquieting passions, the healthy calls of appetite will scarcely be known, and digestion and nutrition will be equally impaired—for it is literally true that "indigestion, or, to use the term of the day, a *bilious attack, as often arises from over-exertion or* ANXIETY OF MIND, as from refractory food."†

* Cumberland's Memoirs, vol. ii., p. 204.
† Art of Invigorating Life, 3d ed., p. 173.

This fact is exemplified on a large scale in every commercial country, and especially in times of *public distress* and *political change*. Shakspeare obviously had the principle in view when he made Cæsar exclaim—

"Let me have men about me that are *fat*,
Sleek-headed men, and such as sleep o' nights.
Yond' Cassius has *a lean and hungry look*;
He thinks too much: such men are dangerous.
Antony. Fear him not, Cæsar, he's not dangerous;
He is a noble Roman, and well given.
Cæsar. *Would he were fatter*:—But I fear him not:
Yet if my name were liable to fear,
I do not know the man I should avoid
So soon as that spare Cassius.—He reads much,
He is a great observer, and he looks
Quite through the deeds of men; *he loves no plays*
As thou dost, Antony; he hears no music:
Seldom he smiles, and smiles in such a sort
As if he mocked himself, and scorned his spirit
That could be moved to smile at any thing.
Such men as he be never at heart's ease
Whiles they behold a greater than themselves,
And therefore are they very dangerous."

Mere experience must have taught every one with what zest he sits down to enjoy the pleasures of the table, and how largely he inclines to eat, when the mind is free, unburdened, and joyous, compared with the little attention he bestows on his meals when he is overwhelmed with anxiety, or has the whole mental energies concentrated on some important scheme. There cannot be a doubt, indeed, that the over-exertion and excitement, or absolute inertness, of mind, in which sedentary people are generally immersed, contributes greatly, along with the want of muscular exercise in the open air, to impair the tone of the digestive organs. In this way, as Dr Caldwell not less justly than forcibly remarks, "dyspepsia *commences* perhaps as often in the brain as in the stomach. Possibly oftener. That this is true of the disease in Europe will scarcely be denied, after a fair examination of the facts connected with it. It is there almost exclusively a complaint of the studious and the scheming, who, overtasking their brains, injure them by toil. Among the husbandmen of England, who steadily pursue their tranquil mode of life, regardless of the fluctuations of stock, the bickerings of party, the fate of political measures, and the changes of place, dyspepsia is almost a stranger." "In the cities,

the same is, in a great measure, true of merchants, manufacturers, and mechanics, who are engaged in a regular and well-established business, which is fully understood by them, where the risk is slight and the profits sure, and no disquieting anxiety attends it. Such individuals have a good digestion, and bear the marks of it. But with literary men, officers of state, dealers in scrip, daring adventurers, and anxious and ambitious projectors of improvements, with these and every other brain-worn class of persons, the case is different. Dyspepsia is their torment, and they exhibit deep traces of it in their lean frames and haggard countenances. Yet are they much more select in their diet, both as respects quantity, quality, and cooking, than the classes to whom dyspepsia is unknown. This fact is notorious, and has been so for centuries. Nor can it be attributed, I think, to any other cause but excessive and deleterious cerebral irritation in the one case, and an exemption from it in the other; and this cause seems sufficient to solve the problem."*

In denouncing active exertion of mind or body immediately after eating as inimical to digestion, I do not mean that we should go to sleep, or indulge in absolute listlessness. A weak constitution may require something like complete repose, but a person in ordinary health may indulge in a leisurely saunter or pleasant conversation, not only without injury but with positive benefit; and perhaps there is no situation in which digestion goes on so favourably as during the cheerful play of sentiment in the after-dinner small-talk of a well-assorted circle. The nervous stimulus sent to the stomach is then of the most healthful and invigorating description, and even the dyspeptic, if on his guard against a heavy meal, forgets his woes amidst the unwonted vigour of his functions.

It is true that thousands who habitually neglect the observance of the condition here adverted to, continue to live and digest for years without appearing to suffer much from their conduct. But it is not less true that there are many more who bring wretchedness and disease upon themselves and their offspring in the vain attempt to counteract the intentions of Nature, and that there are comparatively few even of the former, so happily constituted as to escape entirely unscathed. Most frequently the evil consequences are only accumulating, and when they are summed up at the end of years, the victim finds himself more severely punished than he had ever expected to be. In this respect, the consequence resembles that arising from breathing in a vitiated atmosphere. The effect may not be perceptible for a time; but if God has ordained a pure air to be best adapted for respiration, we have the infallible authority of His omniscience for believing that one which is vitiated *must* be less wholesome, although His beneficence has so constituted us that the injury resulting from it is gradual in its infliction, for the very purpose of giving us time to escape. In like manner, if bodily and mental relaxation are favourable to digestion, we have the same infallible assurance that every departure from them *must* be in so far hurtful, however slowly the effect may develop itself.

* Caldwell's Thoughts on Physical Education, p. 94.

CHAPTER XII.

THE DIFFERENT KINDS OF CONSTITUTION AND OF FOOD, CONSIDERED WITH RELATION TO EACH OTHER.

Man remarkable for the variety of his food—advantages of this—Man not guided by instinct to the choice of his food, but by observation and experience—his welfare thus intrusted to himself—Principle on which fitness of food ought to be determined—information still much wanted—Nature of constitution to be considered—Varieties of constitution or temperament—the lymphatic, nervous, sanguine, bilious, and mixed temperaments—Diet ought to be modified according to temperament—illustrations—Different kinds of food—their classification and division into animal and vegetable—Dr Beaumont's table shewing time of digestion of different articles—General results as to the comparative digestibility of animal, vegetable, and liquid food—Why animal food is most quickly digested; and highly-concentrated food injurious; and the digestive apparatus longer in herbivorous than in carnivorous animals—Doctrines of the modern school of chemical physiology—Food, in order

to permanently support life, must contain albuminous principles—Can the protein compounds be formed in the body?—Origin of fat—Albuminous food becomes muscle before it can support respiration—Necessity of exercise to persons who live fully—and to carnivorous animals—No single article of diet will long support life—Reasons of this—The kind and quantity of food must vary with the kind and quantity of the matter wasted by the body—Principles which food must contain—Diseases from deficiency of some of them—Londe's propositions regarding the comparative digestibility of animal and vegetable food, and other subjects connected with digestion—Animal food and its varieties—its chemical composition no test of its dietetic qualities—Division into fibrinous, gelatinous, and albuminous meats—Adaptation of each of these to different temperaments, ages, and states of health—Vegetable aliments and their properties—principal divisions of them, and remarks on their intestinal digestion, laxative quality, use and adaptation—The arguments of Sylvester Graham and his followers in favour of an exclusively vegetable diet considered.

THE next subject which presents itself for examination, is the kind of food best adapted for the support and nourishment of man.

Man, considered as an organized being, is almost as remarkable for the great variety of substances which he renders subservient to his own support, and the great variety of ways in which he prepares them for his use, as, considered in his mental constitution, he is remarkable for the number and nature of his moral and intellectual endowments. In the former respect, indeed, he forms as great a contrast with many of the lower animals as he does in the latter. Under the guidance of a special instinct, most animals select at once that kind of food which Nature has destined for their use, and abide by it through life with a constancy which dreams not of change. Man, on the other hand, impelled by the love of variety, not only exerts his ingenuity to the uttermost to give new forms to his food by means of cookery, but diligently ransacks every quarter of the globe, and lays earth, sea, and air, under contribution for the supply of his table, and the gratification of his palate.

This difference in the mode of action of the appetite for food in man and animals, bears a direct relation to the circumstances in which he and they are respectively intended to exist. As a general rule, the lower animals are restricted to a comparatively limited locality or climate, and the whole course of their lives runs on in one almost unvarying round. They consequently neither require nor seek for any unusual change of diet, except under the pressure of actual want. With man, however, the case is widely different. He is often called upon to quit the country of his birth, and to expose himself to such vicissitudes, even when living under the same climate, as would render continued existence impossible, if he also were restricted to uniformity of diet. In him, consequently, *appetite* is not an instinct which points unerringly to the proper objects of its own gratification, but is in a great measure a blind impulse, which can be safely guided only by the aid of knowledge and reflection. Without these to direct us in our choice of food, surrounded as we are by many substances endowed with the most opposite qualities, and the external appearance of which affords no clear indication of their wholesomeness or insalubrity, we should stand in the midst of creation far more helpless than any of the inferior animals, and should frequently be poisoned through ignorance, where, with our present constitution, it is easy for us to find both safety and support. It is for ourselves, then, to decide whether we shall earn health and comfort by making ourselves acquainted with the properties of the different kinds of food, and conforming to the principles by which their use ought to be regulated, or risk the loss of both by indolently giving ourselves up to the blind guidance of appetite, and eating whatever comes in our way. I need not waste argument to shew that the former alternative is that which will recommend itself to every reasonable being.

In judging of the fitness of any aliment as an article of diet, we must not rest satisfied with inquiring into its own properties merely. It is essential also to take into account the nature of the living and organized system upon which it is to act, and the relation in which the two stand to each other. The bodily constitution differs so widely in different persons, that the food which is suitable in one instance may be very

much the reverse in another. Even at different ages, and under different circumstances of health and occupation, the same food which formerly proved salubrious, may now prove detrimental to the very same individual. The true philosophy of diet, then, I cannot refrain from repeating, consists less in an acquaintance with the abstract properties of different alimentary substances, than in the power of *accurately adapting the kind of food to the peculiarities of the individual constitution at the time it is administered.* Viewing the latter, then, as the great object to be attained, I shall offer a few remarks, *first*, on the nature and varieties of the human constitution; *secondly*, on the different kinds of food and their distinguishing properties, so far as not already explained in Chapter III.; and, *thirdly*, on the principles by which we should be guided in attempting to adapt the one to the other. To do full justice to these topics would require an extent of detail incompatible with the limits of a work like this, and also an extent of knowledge which as yet does not exist. But, notwithstanding my inability to treat them in the way their importance deserves, I think it better explicitly to avow that inability, and direct the attention of others to the means of increasing our knowledge, than to conceal the deficiency by passing it over in silence. It is true that we cannot hope ever to obtain rules of conduct strictly and minutely applicable to every individual; because to do so would require us to investigate the action of every variety of food upon every form of constitution under every possible variety of circumstances—a proceeding obviously beyond the limits of the human powers. But for practical purposes, fortunately, no such extreme minuteness of research is necessary, and we may safely rest satisfied with a knowledge of principles far less difficult of discovery, and, at the same time, easily applicable, by the aid of reflection, to all the ordinary varieties and conditions of man.

Principal varieties of the human constitution.—On examining the structure and mode of action of the human body in different individuals and at different ages, remarkable differences are observable in the proportions which the various organs and functions bear to each other, and to the system of which they form a part. In one individual, the brain and nervous system predominate over the rest of the organism, and impart to the whole a character of unusual sensibility; in another, the nervous system is feebly developed, and the body presents the soft, rounded appearance, and slow, heavy action, arising from the predominance of the lymphatic system; while in a third, the muscular or the sanguineous organs are in powerful proportion, and impart a vigorous and enduring energy to all the bodily functions. Strictly speaking, every person has a constitution peculiar to himself, and arising out of the peculiar relations which his different parts bear to each other; nevertheless, we meet with many constitutions which resemble each other so much in their essential features, that, for all practical purposes, they may be advantageously grouped together and considered as identical. Taking this general view, we may describe four great classes of constitutions or temperaments as primary or fundamental, because all the others may be compounded from them. These four primary temperaments are, the *lymphatic*, the *nervous*, the *sanguine*, and the *bilious*. The temperaments arising from the combination of two or more of these are termed the *mixed* or *compound* temperaments, and they derive their distinctive names from those of their constituent elements. Thus, a predominance of the nervous and lymphatic elements constitutes the *nervous-lymphatic* temperament; a mixture of the sanguine and nervous, the *sanguine-nervous*; a mixture of the sanguine and bilious, the *sanguine-bilious*; and so on; the name of the temperament which appears to be in the ascendant being always placed first in order.

The *lymphatic temperament* is distinguished by the predominance of the white vessels or lymphatic system, the

full, rounded, heavy appearance, fine transparent skin, soft hair, imperfectly-formed blood, languid circulation and expression, flaccid and feeble muscles, and general inactivity and feebleness of mind and body. The nutritive functions predominate over the others; but even these are imperfectly performed, and the system consequently wants that elasticity and tone which result from perfect nutrition, and is deficient in that inward stimulus which impels to activity. The tendency to indolent inaction increases with the corpulence which, if there be full living, is a natural feature of this temperament. The feeble powers of the system are thus overloaded and oppressed, and frequently give way with dropsical symptoms. In infancy and childhood, when rapid nutrition is required, the lymphatic temperament is well marked; but it is then modified in many of its features by the activity of the nervous system. As a general rule, also, it is more prevalent in women than in men; which is one cause of the greater addiction of the former to sedentary pursuits.

From the inferior activity and strength accompanying the lymphatic temperament, individuals in whom it predominates are unfit for continued or severe exertion, and, when roused by a strong stimulus, their excitability is soon exhausted. The habitual tendency is to indolent inaction, or the *dolce far niente*. As a natural consequence, the peculiarities of this temperament are aggravated by a sloppy, soft, and unstimulating diet, and diminished by the use of concentrated, nourishing, and rather stimulating food.

The *nervous temperament* is characterised by the predominance of the brain and nerves, and consequently by high nervous sensibility, or excitability. It is distinguished by delicacy of fibre, fine thin skin, sharp expressive features, fine hair, susceptibility of external impressions, and high activity soon wearing itself out. Hence vivacity alternating with depression, and a tendency to extremes. It is most remarkable in females of the higher ranks, and abounds most in highly civilised communities. In children also this temperament is well marked; but in them, as in women, its influence is generally modified by a mixture of the lymphatic constitution. The late hours, heated rooms, and numerous excitements of modern society, greatly assist in the production and aggravation of the evils consequent on an excess of the nervous temperament. To correct this tendency, a mild and plain but nourishing diet, a tranquil mode of life, regular but not excessive occupation of mind and body, ample exercise in the open air, and bathing, are highly useful.

The *sanguine temperament* is indicated by the predominance of the apparatus of sanguification, the large capacity of the chest, the volume and susceptibility of the heart, the abundance and richness of the blood, and great development of the bloodvessels; a fine skin, fine light or reddish hair, florid complexion, and elastic activity of mind and body. Under the use of stimulants and exciting food, this activity is apt to pass into inflammatory action, and hence a mild and unexciting diet is the most suitable.

The *bilious temperament* is that in which the biliary and muscular functions seem to predominate, and is indicated by a dark yellow or brownish complexion; short, dark, crisp hair; a dry, lean habit of body; well-defined and firm muscles; prominent veins; a dry, brown, rather coarse skin; expressive dark eyes; and general energy of constitution. The characteristic feature of this temperament is enduring activity, not passing so easily into excitement as in the nervous, nor yet so easily exhausted as in the sanguine.

Such are what may be called the primary temperaments; but the varieties arising out of their admixture in different proportions are very numerous. Thus, from the combination of the lymphatic and sanguine, is derived a temperament which participates in the qualities of both, and which is very common in children and women. In like manner, the bilious may

be combined with the nervous, and produce a mixed temperament, characterised by a keener sensibility than the pure bilious, and a more sustained and energetic activity than the pure nervous. In the same way, other modifications of temperament may be formed; but for a more full explanation of them, I must refer the reader to any of the standard works on physiology.

Such being the great variety of constitutions among mankind, and so strikingly different being in many of them the predominant properties by which they are respectively characterised, the reader will at once perceive that the kind of diet which is suitable to one person, may prove very unsuitable to another of a dissimilar temperament; and that, when laying down dietetic rules, we must, as already observed, attend not only to the qualities of the food itself, but to those of the constitution for which it is recommended.

When the original temperament is of a strongly-marked kind, the influence of diet and external circumstances in modifying it is very limited; and then our chief aim ought to be to adapt the mode of life to the peculiarities by which it is distinguished. For example, if a youth possesses the characteristic features of an energetic bilious-sanguine temperament, prudence recommends that we should enjoin moderation in the use of stimulants, and place him in a profession affording ample scope for mental and muscular activity. If we neglect these indications, and engage him in purely sedentary pursuits, at the same time allowing him a free and generous diet, his health will soon fail, and he will sigh in misery for liberty and action. If, on the other hand, we restrict a slow lymphatic youth to a very mild and soft diet, and place him in a situation requiring promptitude and energy of action, and an ever-wakeful attention, he also will suffer; because the plain and unstimulating food which is very fit for a person of a highly excitable temperament, will depress still further his already feeble energies, and prove insufficient for the support of his health. If, again, a stimulating regimen be pursued by a person of an already excitable temperament, the high natural activity will probably be carried so far as sooner or later to induce disease. Hence, it is indispensable, especially in training the young, that due regard be paid to the adaptation of the diet to the peculiarities of the individual constitution from the earliest period of life.

When the temperament is of a mixed kind, the influence of regimen and education in modifying the original constitution is much greater, and consequently much may be done by judicious treatment to remedy defects or improve what is good. This is especially the case when, in the measures we adopt, we take advantage of those natural modifications of temperament which occur, to a greater or less extent, as growth and life advance. During the transition from infancy to childhood, for example, the temperament which was at first almost purely lymphatic, and marked by the predominance of the nutritive functions and a tendency to almost constant sleep, gradually becomes more and more nervous as the feelings and general sensibility awaken to activity. At a later stage, again, the temperament becomes modified by the increasing development of the organs of sanguification, as evidenced by the enlarged capacity of the heart, lungs, and chest; and in accordance with this change, the nervous sensibility becomes less acute, and the desire for bodily activity increases, until, with many, it becomes almost a passion. When growth is fairly completed, and active nutrition and abundance of rich blood are less urgently required, the steady and enduring activity of the bilious temperament comes proportionally more into play, and is more suitable to the increasing gravity of the duties which then occupy the mind. Accordingly, it is only in mature age that the principal features of this temperament are found in their most marked form. In each of these stages some modification of diet is required, if we wish to aid the efforts of

Nature, and to obtain the highest degree of health and efficiency of which the constitution is susceptible. As yet, however, but little attention has been paid to this subject, and much remains to be ascertained with regard to it.

In adapting the mode of living to particular constitutions, it will be of great assistance to us to have a clear perception of the precise object we wish to attain, and know whether we should develop or repress the predominant temperament. For example, if a child is characterised by a highly lymphatic temperament, we can be at no loss to determine that every effort should be made to repress its predominance, and to increase the proportion of the sanguine, bilious, and nervous elements. With this view, a dry, airy locality, with a good exposure, should be selected; and the diet, instead of consisting of slops, broths, and bulky kinds of food, should be composed chiefly of concentrated and moderately stimulating aliments, such as beef, mutton, curries, spices, coffee, &c., given in moderate quantity and at proper intervals. If, however, the person be of a purely nervous temperament, the same course of management will be highly injudicious, as it will increase the tendencies which are already in excess. In this latter case, mild nourishment, with avoidance of excitement, is the most proper regimen. In constitutions of a mixed kind, again, the best regimen is that which includes sufficient variety to sustain the respective functions in due and proportionate activity. But if from any cause it be considered desirable to cherish any individual element of a mixed temperament more than another, the regimen ought of course to be modified to meet that exigency.

If we now inquire how far the diet of the young is regulated in families with reference to peculiarities of constitution, we shall find that no such thing is thought of by parents except during sickness: children of every age and temperament are brought up on precisely the same kind of food; or, if any difference is made, it consists in the liberty sometimes granted to a child to eat more or less of any particular dish, according as taste or caprice may direct its choice. And yet there is abundant evidence to shew that great and permanent good or evil may be effected according to the fitness or unfitness of the diet to which the individual is thus accidentally subjected. In Chapter XIII. I shall be able to expound this branch of the subject with more advantage to the reader than in this place; at present, I pass on to the consideration of the different kinds of food which are used for the nourishment of man.

The different kinds of food may be classified according either to their elementary composition, as ascertained by chemical analysis, or to their general properties, as ascertained by observation. In the present state of our knowledge, the latter is the only ground of classification which can be of any practical use in the regulation of diet, and it is, therefore, the one which I shall prefer.

It is important to remark, in the first place, that no substance which is not itself organised—in other words, which is not a part of some animal or vegetable—can be used as food, or serve for the nourishment of man. Even the various earths and salts which enter into our composition (except what are contained in the water we drink, and the salt we use as a condiment), are derived exclusively from the other organised substances that are consumed in the form of food. The first great division of aliments, therefore, is into ANIMAL and VEGETABLE; but before treating of the respective properties of each in their relation to the human system, it will be useful to make some remarks on the comparative readiness with which they are acted upon in their progress through the stomach and intestinal canal.

In the investigations of Dr Beaumont, already so often referred to, the comparative digestibility of different kinds of food was a subject to which he devoted considerable attention; but his experiments made for its elucidation are, like those of most of his pre-

decessors, rendered of little value by the vague way in which they seem to have been conducted, and the usual omission of all particulars in regard to those conditions which are known to exert a powerful influence on the progress of digestion.

The following Table, which I have arranged in a more lucid order than Dr Beaumont has done, exhibits the general results of all the experiments made upon St Martin posterior to 1825; and the average is deduced from those which were performed when the stomach was considered by Dr Beaumont to be in its natural state, and St Martin himself subjected to ordinary exercise.

TABLE shewing the Mean Time of Digestion of the different Articles of Diet.

Articles of Diet.	Mode of Preparation.	Time required for digestion.	
		H.	M.
Rice	Boiled	1	
Pig's feet, soused	Boiled	1	
Tripe, soused	Boiled	1	
Eggs, whipped	Raw	1	30
Trout, Salmon, fresh	Boiled	1	30
Trout, Salmon, fresh	Fried	1	30
Soup, barley	Boiled	1	30
Apples, sweet and mellow	Raw	1	30
Venison steak	Broiled	1	35
Brains	Boiled	1	45
Sago	Boiled	1	45
Tapioca	Boiled	2	
Barley	Boiled	2	
Milk	Boiled	2	
Liver, beef's, fresh	Broiled	2	
Eggs, fresh	Raw	2	
Codfish, cured, dry	Boiled	2	
Apples, sour and mellow	Raw	2	
Cabbage, with vinegar	Raw	2	
Milk	Raw	2	15
Eggs, fresh	Roasted	2	15
Turkey, wild	Roasted	2	18
Turkey, domestic	Boiled	2	25
Gelatine	Boiled	2	30
Turkey, domestic	Roasted	2	30
Goose	Roasted	2	30
Pig, sucking	Roasted	2	30
Lamb, fresh	Broiled	2	30
Hash, meat and vegetables	Warmed	2	30
Beans, pod	Boiled	2	30
Cake, sponge	Baked	2	30
Parsnips	Boiled	2	30
Potatoes, Irish	Roasted	2	30
Potatoes, Irish	Baked	2	30
Cabbage, head	Raw	2	30
Spinal marrow	Boiled	2	40
Chicken, full grown	Fricassee	2	45

TABLE shewing the Mean Time of Digestion—*continued*.

Articles of Diet.	Mode of Preparation.	Time required for digestion. H.	M.
Custard	Baked	2	45
Beef, with salt only	Boiled	2	45
Apples, sour and hard	Raw	2	50
Oysters, fresh	Raw	2	55
Eggs, fresh	Soft boiled	3	
Bass, striped, fresh	Broiled	3	
Beef, fresh, lean, rare	Roasted	3	
Beef-steak	Broiled	3	
Pork, recently salted	Raw	3	
Pork, recently salted	Stewed	3	
Mutton, fresh	Broiled	3	
Mutton, fresh	Boiled	3	
Soup, beans	Boiled	3	
Chicken soup	Boiled	3	
Aponeurosis	Boiled	3	
Cake, corn	Baked	3	
Dumpling, apple	Boiled	3	
Oysters, fresh	Roasted	3	15
Pork-steak	Broiled	3	15
Pork, recently salted	Broiled	3	15
Mutton, fresh	Roasted	3	15
Bread, corn	Baked	3	15
Carrot, orange	Boiled	3	15
Sausage, fresh	Broiled	3	20
Flounder, fresh	Fried	3	30
Catfish, fresh	Fried	3	30
Oysters, fresh	Stewed	3	30
Beef, fresh, dry	Roasted	3	30
Beef, with mustard, &c.	Boiled	3	30
Butter	Melted	3	30
Cheese, old, strong	Raw	3	30
Soup, mutton	Boiled	3	30
Oyster soup	Boiled	3	30
Bread, wheaten, fresh	Baked	3	30
Turnips, flat	Boiled	3	30
Potatoes, Irish	Boiled	3	30
Eggs, fresh	Hard boiled	3	30
Eggs, fresh	Fried	3	30
Green corn and beans	Boiled	3	45
Beet	Boiled	3	45
Salmon, salted	Boiled	4	
Beef, fresh, lean	Fried	4	
Veal, fresh	Broiled	4	
Fowls, domestic	Boiled	4	
Fowls, domestic	Roasted	4	
Ducks, domestic	Roasted	4	
Soup, beef, vegetables, and bread	Boiled	4	
Heart, animal	Fried	4	
Beef, old, hard, salted	Boiled	4	15

TABLE shewing the Mean Time of Digestion—*continued*.

Articles of Diet.	Mode of Preparation.	Time required for digestion. H.	M.
Pork, recently salted	Fried	4	15
Soup, marrow bones	Boiled	4	15
Cartilage	Boiled	4	15
Pork, recently salted	Boiled	4	30
Veal, fresh	Fried	4	30
Ducks, wild	Roasted	4	30
Suet, mutton	Boiled	4	30
Cabbage, with vinegar	Boiled	4	30
Suet, beef, fresh	Boiled	5	3
Pork, fat and lean	Roasted	5	15
Tendon	Boiled	5	30

This table is interesting, but the results must not be too much relied upon, or regarded as representing the *uniform* rate of digestibility. We have already seen that chymification is greatly influenced by the interval which has elapsed since the preceding meal, by the amount of exercise taken, the keenness of the appetite, the state of the health and mind, the completeness of the mastication, the state of rest or exercise after eating, and various other circumstances; and, above all, *the quantity swallowed in proportion to the gastric juice secreted*. It is plain, therefore, that if an experiment be made without regard to these conditions, and without anything being recorded except the time occupied in digestion in the individual case, the conclusions deduced from it may be most fallacious. The very aliment which, taken in full quantity, remains on the stomach for hours, may, in a smaller quantity, be entirely digested in one-third of the time. Thus, in the foregoing table, two and a-half hours are set down as the average period required for the chymification of jelly; and yet, in one of Dr Beaumont's experiments, we find that eight ounces of that substance were entirely digested in *one* hour. So that, if all the other conditions are not carefully kept in view at each trial, the results cannot possibly be held as conclusive.

It may be said that, on the occasion just alluded to, St Martin's digestion must have been particularly good—and, in truth, it seems to have been so; for at nine o'clock A.M. he breakfasted on *soused tripe, pig's feet, bread and coffee*, and yet, only *one* hour later, no vestige of any of these savoury things remained in the stomach. What renders this result the more remarkable, is the fact, that, in another table, a simple breakfast of coffee and bread is set down as having required FOUR hours for its digestion. The rapid disposal of the same elements with the addition of soused tripe and pig's feet, instead of disproving my position, evidently strengthens it, by shewing that, if *from any cause* the digesting power varies in intensity, the result obtained from the experiment on one kind of food, cannot, with any show of reason, be considered as an accurate index of its rate of digestibility in comparison with that of other kinds.

This neglect of the other conditions is accordingly the circumstance which throws a doubt over the results not only of Dr Beaumont's experiments, but of those of every other inquirer. Indeed Dr Beaumont himself candidly admits, that his were performed for the purpose of demonstrating other important principles connected with digestion, and not at all with the view of determining the comparative rates

of digestibility of different kinds of aliment; and in alluding to the various requisites for a satisfactory series of experiments, he justly states, that this would be a Herculean task which it would take years to accomplish. It ought farther to be observed, that the foregoing table cannot, in strictness, be regarded as shewing aught but the time which the different articles of food required to *disappear from the stomach;* for it by no means necessarily follows that they had then undergone *complete digestion.* On the contrary, the most indigestible articles may have disappeared sooner than others of comparatively easy digestion; nay, we shall afterwards see that this really happens—for, in cases where a fistulous opening into the intestines existed, it was found that vegetables appeared at the opening in an almost undigested state, long before the well-formed chyme of animal food shewed itself. The very statement which we find in Dr Beaumont's table, that raw cabbage required only 2 hours for digestion, while 4½ were necessary when it was boiled, is of itself sufficient to shew that some source of fallacy must exist. In considering the following general results, then, the reader should bear in mind that they are only probable and approximative, and are not to be regarded as strictly demonstrated or certain.

1. As a general rule, animal food is more easily and speedily digested, contains a greater quantity of nutriment in a given bulk, and therefore satisfies hunger for a longer time, than either herbaceous or farinaceous food; but, from causes which will afterwards be explained, it is also more heating and stimulating. *Minuteness of division,* and *tenderness of fibre,* are shewn by Dr Beaumont's experiments to be two grand essentials for the easy digestion of butcher-meat; and the different kinds of fish, flesh, fowl, and game, are found to vary in digestibility, chiefly in proportion as they approach or depart from these two standard qualities.

2. Farinaceous food, such as bread, rice, sago, arrow-root, or gruel, is also rapidly assimilated, and proves less exciting to the system than concentrated animal food; but as it affords less stimulus to the muscular coat, and causes less vascular action in the mucous, from not being, in an equal degree, dependent on the gastric juice for its digestion, its exclusive use for any length of time seldom fails to weaken the stomach and impair digestion. For the same reason, however, it becomes a very suitable aliment where stomachic irritation already exists. When the stomach is in a healthy state, milk is digested almost as easily as farinaceous food, and is nearly as unstimulating.

3. The other kinds of vegetable substances are the slowest of all in undergoing digestion, and the fibrous portion of most of them passes out of the stomach and through a part of the bowels comparatively little changed; and hence the uneasiness which their presence often excites in the lower intestines, especially in persons of weak digestion. In a given bulk they contain less nutriment, and excite the system less, than any other kind of food; so that they are well adapted for the diet of those in whom it is necessary to avoid every kind of stimulus, and who are not subjected to great muscular exertion: but to a person undergoing hard labour, they afford inadequate support.

4. Liquid food—soup, for example—does not call into play the muscular coat of the stomach, and is so slow of digestion where that organ is already weakened, that it often gives rise to acidity, and hence is unfit for most dyspeptic patients. Before the gastric juice can act upon it, the fluid part must be absorbed, and the mass thickened to a proper consistence for undergoing the usual *churning* motion. On examining the contents of the stomach an hour after St Martin had dined on beef-soup, Dr Beaumont, it will be remembered, found that on one occasion the absorption of the watery part had been carried so far as to leave the remainder of even a thicker consistence than after an ordinary solid meal: but a similar result follows only when the digestive powers are very vigorous. When the blood is watery,

and the secretions are languidly performed, absorption goes on slowly in the stomach, and in such cases soups form an improper article of diet. They are apt to pass into acetous fermentation, and to produce heartburn, and occasionally diarrhœa. When drink is swallowed, it is also carried off by absorption, and is not digested or allowed to pass through the pylorus. One purpose of this provision seems to be to prevent the gastric juice from being rendered inefficient by too much dilution.

When the food on which an animal lives is of a highly-concentrated kind, and contains much nourishment in a small bulk, the apparatus of organs provided for its digestion is on a correspondingly small scale in point of extent. Thus, in carnivorous animals, whose food is, bulk for bulk, the most nutritious of all, the stomach and intestines are simple and short, the length of the latter not being more than from one to four or five times that of the body. In herbivorous animals, on the other hand, whose food is sparingly nutritious, and therefore requires to have a large bulk or volume, the stomach, as we saw in a former chapter, is greatly more complicated, and the length of the intestines enormously increased.—(See p. 25.) In the elephant, and some other herbivorous animals, we find the capacity to depend, not on the length, but on the width and increased surface of the intestine—in other words, on the greater calibre of its cavity. Man, being intended to feed on both animal and vegetable substances, possesses an organization which holds an intermediate place between the two extremes. In him the intestines neither are so short as in carnivorous animals, nor have the complexity and length characteristic of the herbivorous—thus shewing the intentions of Nature in regard to his food, and at the same time allowing him a considerable latitude of adaptation when the force of circumstances for a time denies him access to any variety.

Animal food being in general more quickly digested than vegetable, and a simpler organization being sufficient for its assimilation, many physiologists have inferred that this is owing solely to its being already of an animal nature, and therefore requiring scarcely any change to fit it for becoming a constituent part of the living fibre. Indeed, according to the modern school of chemical physiology, the stomach possesses no power of forming new compounds of a type different from that of the substances submitted to it for digestion; its function being limited to separating from the mass of food those proximate elementary principles which are already contained in it, and presenting them to the vessels in a state fit for absorption; or at most of altering the combination of the elements, without essentially changing their chemical nature. Thus, it is absolutely impossible for the stomach to prepare muscular fibre from starch or fat, because these substances contain no albuminous principle from which muscle could be formed. Accordingly we see that, if a dog be fed on starch exclusively, it begins almost immediately to lose flesh, and dies before the lapse of many days, simply because the starch cannot repair the waste of those principles, the elements of which do not belong to its own composition. Again, if fat be made use of as an exclusive article of diet, the animal apparently retains its flesh, but nevertheless dies. Here, too, the reason is waste unaccompanied by adequate nutrition; although the fat, from its deposition in the tissues, conceals the loss which the flesh has undergone. On dissection, the muscles are found to have wasted away—an inevitable result, since it is quite impossible for fat, which contains no nitrogen, to repair the waste. All food, therefore, in order to be capable of permanently sustaining life, must contain one or more of the albuminous principles.

In the third chapter we directed the reader's attention, in a very general manner, to the nitrogenous articles of diet as destined to repair the waste of the system, and to the non-nitrogenous as the aliment of respiration. This

division of food, though sufficiently correct for all practical purposes, is liable to objection in so far as the adipose and nervous tissues may be nourished by non-nitrogenous articles of food. We may, however, venture to regard the adipose as a fortuitous, rather than an essential tissue of the body; and a moment's consideration will shew, that as the quantity of material necessary to repair the waste of the nervous tissue is exceedingly small, the source whence it is derived is a a matter of little practical importance, as far as the regulation of diet is concerned. The brain, in a hundred parts, contains eighty of water, seven of albumen, and only five of a phosphorised fat; which last may, in all probability, be formed from either nitrogenous or non-nitrogenous substances. If, now, we bear in mind that the whole nervous system scarcely exceeds 50 oz. in weight, and that the nervous tissue is the most stable in the body, scarcely losing weight by starvation, and not gaining by fattening, we may, without hesitation, adhere to the division of food which has been adopted throughout the present work.

According to the modern chemico-physiological school, the albuminous or nitrogenous principles must be derived, in the first place, from the vegetable kingdom. Fibrin, casein, and albumen, for instance, are all to be regarded as originally vegetable productions; and the "mission" of the cow and the sheep is to separate them, by means of a complicated digestive apparatus, from the large mass of extraneous matter with which they are associated, and to present them to man and the carnivorous animals in a concentrated form. Some vegetables, such as beans, pease, the different varieties of grain, and certain nuts, contain the albuminous principles already sufficiently concentrated to supply man with aliment capable of repairing the waste of all the tissues; but his digestive apparatus would prove insufficient to collect those principles in the necessary quantities from grass and other succulent vegetables. When the food on which an animal lives contains but a comparatively small amount of nutritious matter, we find that the quantity eaten is proportionally great; and thus, while the contents of the alimentary canal of a rabbit weigh a fourth of the whole weight of the animal, the contents of those of a cat (the stomach being filled with half-digested meat) have been found to weigh only a twenty-first part of its weight, and not more than an eighty-first part when the stomach is empty. The disciples of Liebig and Dumas, then, are of opinion that protein compounds cannot be *formed* in the system; but, although the facts adduced in support of this doctrine certainly have much weight, physiology is not yet sufficiently advanced to authorise us to receive it as beyond all suspicion. According to the theory of Liebig, wild-growing plants derive their nitrogen from the ammonia which is found in minute quantities in the atmosphere, as the result of the decomposition of animal and vegetable substances, and their carbon from its carbonic acid; the use of manure being merely to increase, by its decomposition, the supply of ammonia and carbonic acid, and thus to accelerate the growth of the plants.* In assuming the former part of this hypothesis, it is necessary to assume also that the original constitution of the atmosphere was different from what it now is; since the original plants must have derived their nitrogen from some other source than the ammonia produced by decomposition. Indeed, until very lately, vegetable physiologists were of opinion that plants possess the power of appropriating the nitrogen of the atmosphere, but this belief has been generally renounced since the discovery of ammonia as a constituent of atmospheric air. The question, however, notwithstanding Liebig's very plausible reasoning, cannot be regarded as decided; and many physiologists consider it by no means improbable that the nitrogen of the atmosphere may unite, under certain circumstances, with hydrogen in the nascent state to form ammonia, so that plants may be supplied with

* For a full exposition of Liebig's views, see his work on the Chemistry of Agriculture.

it independently of decomposition. It has, moreover, been suggested as possible, that the system may have the power of assimilating minute quantities of the nitrogen of the atmospheric air inhaled in respiration; but no proof has been advanced in support of this theory, which is indeed in direct opposition to our present knowledge. These remarks are offered, not with the view of calling in question the general truth of the doctrines of Liebig and Dumas, but merely as a caution against adopting them as completely proved in all their details. In the crumbling to pieces of the fabric reared by Mulder and Liebig on the faulty analysis of protein by the former (see page 14), we have lately had abundant evidence that chemists are not always sufficiently cautious in testing their facts before building up their theories.* Everything considered, the probability certainly is, that animals derive all their nitrogen from their food. Boussingault is of opinion, from certain experiments which he undertook, that more nitrogen is furnished to them in their food, than can be detected in the sensible excretions; and hence he concludes, that small quantities must be given off with the exhalations from the skin and lungs.†

Fat is either introduced into the system ready-formed, or may be derived from the digestion of starch and sugar, and other analogous substances. Until very recently Dumas maintained that all animal fat must be derived from the oil and wax of plants; but by repeating Hubert's well-known experiment of feeding bees on pure sugar alone, he convinced himself that they continued to deposit wax, which, of course, must have been derived from the transformation of sugar. He has consequently given in his adhesion to Liebig's doctrine, that farinaceous and saccharine substances may be transformed into fat. This view is farther confirmed by the experiments of Boussingault, who found that pigs gained more fat than could be accounted for as ready-formed in their food, thus proving that the farinaceous or saccharine principles of the aliment must have undergone transformation. But although it is true that in man and the herbivorous animals, fat is formed chiefly by the transformation of the carbonated hydrates, there exists no chemical obstacle to its formation from the protein compounds, though in this case the process is more complicated. If we assume, what is not strictly true, that all the nitrogen of the food is excreted by the kidneys in the shape of urea, then 100 grains of albumen may, by combining with 15·72 grains of oxygen, yield 34·07 grains of urea, 41·92 grains of fat, and 39·73 grains of carbonic acid. But if we suppose the 100 grains of albumen to enter into combination with 152·22 grains of oxygen, the result would still be 34·07 grains of urea, as in the preceding case; but the additional quantity of oxygen would consume all the fat, while 174·03 grains of carbonic acid and 44·10 grains of water would be produced.* It is thus apparent that in order to derive from protein the largest possible amount of animal heat, a free supply of oxygen must be afforded, in order that the requisite transformations may be duly accomplished. Hence arises the instinctive desire which carnivorous animals feel for abundant exercise, and which impels them, even when in

* It is proper to mention here, that Dr Prout dissents from the opinion that no nitrogenous or protein compound can be formed in the system. On the contrary, he regards the formation of albumen from starch as a phenomenon of daily occurrence in the nutrition of animals. He conceives that there is secreted in the liver a highly nitrogenous compound which has the power of uniting with starch, or the products of its digestion, in the duodenum, and thus giving rise to the direct formation of albumen. In support of this hypothesis Dr Prout states, that he has frequently detected albumen in the duodenum of animals whose food was destitute of nitrogen. The occurrence of albumen in the duodenum, however, is no proof that it was formed from non-nitrogenous aliment; for it may have been derived from the pancreatic juice, or from the secretions of the mucous membrane. Dr Prout likewise imagines, that albumen may be formed by the incorporation of the nitrogen of the atmospheric air with non-nitrogenous food during the process of mastication. Both of these hypotheses are unsupported by facts or experiments, and rest merely on the authority of Dr Prout's name. It is impossible to receive them, therefore, till it be shewn that animal life may be supported for a considerable time on food destitute of protein compounds. For Dr Prout's views, see his Treatise on Stomach and Renal Diseases, fifth ed., pp. 499 and 507. London, 1848.

† Annales de Chimie et de Physique, tome xi. 1844.

* Valentin's Lehrbuch, vol. i., p. 777.

confinement, to move restlessly from one corner of their den to the other. If the supply of oxygen is not sufficient to convert the protein compounds into urea and carbonic acid, part of the unconsumed carbon is apt to unite with the nitrogen to form uric acid, a compound of difficult solubility, and which appears in the urine in the form of gravel, and in different parts of the body, particularly on the knuckles, as gout or chalk-stones. Gout, as is well known, is a disease generally attendant upon full living with deficient exercise, and we here recognise its probable cause in the imperfect assimilation of the protein compounds.*

Many physiologists are of opinion, that all albuminous food requires to pass through the condition of muscular tissue in the body, before it can be used as respiratory fuel. According to this view, when a copious meal of animal food is taken and digested, the blood is increased in a corresponding ratio, and if no exercise be taken to cause waste of the muscles, no call is made upon the blood for a supply, and, consequently, each additional meal adds to the amount of the blood, till indigestion, apoplexy, or some other serious accident ensue. The reader will here recognise another powerful reason for abundant exercise with full living: the muscular tissue must be wasted by exercise, in order that the consequent demand for a fresh supply may keep the blood within the healthy standard. These views are probably too exclusive; for there is reason to think that the blood may be attacked by the oxygen of the inhaled air, without having previously formed part of the tissues. But we need not occupy our space with discussing this question, which indeed is of no practical importance.

It is well known that animal food affords a more stimulating nutriment than farinaceous and other kinds of vegetable aliment, and hence ought to be avoided in diseases of excitement. But it seems to me that this stimulus is owing not only to its own inherent properties, but also to its more highly-concentrated state, and to the much greater quantity of blood which is derived from it than from an equal bulk of vegetable aliment. From the numerous experiments of injecting water, poisons, and other substances into the veins, performed by Magendie and others, we have direct proofs that the same agent which, introduced rapidly into the system, will sometimes act so powerfully as to destroy life, will excite scarcely any perceptible disorder if introduced very slowly. Analogy, therefore, bears us out in believing that the rapid admixture of very nutritious chyle with the blood may over-stimulate the system, where its more gradual introduction would have produced no such effect. At the same time, we cannot doubt that there is also a greater inherent stimulus in animal than in vegetable aliment. It causes the heart to beat with increased vigour, the circulation to become stronger, and the various metamorphoses on which vital action depends to be performed with greater energy. Every-day experience convinces us of this; and the fact is further practically confirmed by the observations of Mr Spalding, the improver of the diving-bell, who found that when he had eaten animal food, and had drunk fermented liquors, he exhausted the air of the bell much sooner than when he had been living on vegetable diet, and drinking water.*

It seems to be partly for the purpose of obviating the evil of a too rapid introduction of nutriment, and partly in order to modify the stimulus, that Nature has rendered a certain bulkiness of food advantageous to digestion, and decreed that no animal can long retain its health if fed on highly-concentrated aliment alone. Dr Paris refers to post-horses fed chiefly on beans and oats, as instances among the lower animals of the insalubrity of too condensed nutriment, and shews that they live constantly on the brink of active disease, and every now and then re-

* The urine of birds contains little if any urea, and is in many composed chiefly of solid urates. It is difficult, in the present state of our knowledge, to reconcile this fact with the reasoning in the text, although it does not necessarily invalidate it. The subject requires further investigation.

* Dr R. D. Thomson on the Food of Animals, p. 28.

quire bleeding, laxatives, and emollients, to keep them in condition. Sportsmen, boxers, and others who train themselves for severe exertion, are additional examples shewing that a similar mode of living induces a morbid tension of the system which cannot be long kept up without danger. The food, therefore, should contain a certain quantity of comparatively innutritious matter; and experience has further shewn that no single article of diet, whether nitrogenous or non-nitrogenous, is capable of sustaining life for any length of time. If a dog be fed solely on sugar, or gelatine, or fibrin, or any other single substance whatever, before many days are over it begins to droop, and speedily dies. The reason is, that *no single alimentary substance is capable of repairing the waste which is going on in every organ of the body.* Carbon must be provided to make good the loss by the excretions of the lungs and liver, nitrogen to replace the materials excreted by the kidneys, and the various earthy and alkaline salts to replace those which are carried off by the alvine and urinary evacuations. The failure of a due supply of any of those substances which are required for the healthy performance of the animal functions, is necessarily followed by disease and death.*

The amount of the waste varies with the circumstances in which the body is placed. In a warm climate, where but little exercise is taken, there is comparatively little waste of the tissues; and consequently but a moderate appetite is experienced for animal food, while the desire for respiratory aliment is likewise small. But in the Arctic Regions, where the generation of heat is all-important, respiratory aliment is supplied in the concentrated form of oil and fat, which is consumed in surprising quantities; and the waste of the tissues is repaired by abundant supplies of the flesh of bears, reindeer, seals, and other animals. In order to supply the wants of the system, the food must contain fibrin, or one of the allied principles, casein or albumen; fat, or starch or sugar from which fat may be formed; and soda, potash, chlorine, sulphur, phosphorus, lime, iron, and other inorganic bodies, which are as essential to the continuation of life as fibrin itself. Chlorine, sulphur, phosphorus, potash, soda, and lime are being continually removed from the system by the urinary and alvine evacuations, and must be replaced, otherwise the gastric juice will cease to be secreted for want of hydrochloric acid, and the bones to be deposited for want of lime and phosphorus. As mentioned in Chapter III., milk, in the healthy state, contains every element necessary for repairing the waste of the body, and therefore is capable of serving as the sole aliment.

The foregoing remarks are well illustrated by the experiments of Chossat, who found that when pigeons were fed with grain, as much being allowed as they chose to eat, but a supply of pebbles or sand being withheld, they were attacked with diarrhœa, gradually lost flesh, and ultimately died in about seven or eight months. Their bones had wasted away and become so brittle as to break with the slightest blow; parts of the breastbone had even lost all earthy matter, and become transformed into cartilage.* If, in addition to the grain, the pigeons were supplied with carbonate of lime, no diarrhœa ensued, and the bones retained

* The same consequences ensue if the products of digestion are not duly assimilated. In the disease termed diabetes, the digestive powers are particularly vigorous, and it is difficult to stay the cravings of the stomach. Large quantities of food are consumed and digested, yet the body, instead of being well nourished, loses flesh rapidly. The cause of the emaciation lies in the non-assimilation of the sugar resulting from the digestion of the saccharine and farinaceous articles of diet. Instead of being burned in the system, and passing off from the lungs in the form of carbonic acid, the sugar is thrown off unchanged by the kidneys, and may be readily detected in the urine. The system is thus deprived of its chief supply of respiratory aliment, and is forced to fall back upon the tissues of the body, which are consequently impoverished. Accordingly, in this state the protein compounds are best adapted for affording nutriment; but, in severe cases of the disease, the assimilation of them also is disturbed, for the emaciation continues notwithstanding the fullest supplies of animal food. Dr Prout remarks that benefit is occasionally derived from the use of well-prepared porter. In this case, the vegetable or saccharine extract has already passed the stage of transformation in which it existed as sugar, and has assumed a form which, in the system, is readily decomposed into carbonic acid.

* Archives du Museum d'Histoire Naturelle, tome ii., p. 438.

their normal condition. As an additional illustration of the necessity of inorganic material, we may mention the case, quoted by Mulder, of a family in which the children suffered repeatedly from fractures of the bones. The cause was traced to an insufficient supply of the phosphate of lime afforded by a low potato-diet. A change to a regimen of meat and rye-bread, by restoring perfect nutrition, removed the disease.

In like manner, if the milk supplied to infants do not contain the due proportion of the salts of lime, it is natural to suppose that they will be attacked with rhachitis, or softening of the bones. This view derives support from the fact, that the diarrhœa with which such children are affected, is often checked by the exhibition of chalk. Dr R. D. Thomson, in his experiments on the food of animals, found that cows which were fed partially on malt, yielded a smaller quantity of milk than when barley constituted part of their diet; his explanation of which is, that "the soluble salts are much diminished in the malt, and hence a larger quantity of the grain would be required than of barley to produce the salts of a given amount of milk."*

Boussingault endeavours to shew, that the increase of the skeleton in young pigs fed on potatoes is impossible without the aid of the lime contained in the water which they drink;† and it is well known that the chlorotic state of young females is owing to a deficiency of iron in the blood, which must be remedied before health can be restored.

The reader will now easily see how the continuance of an unvaried routine of diet may prove injurious to the system, from the food happening to be deficient in some element necessary for the repair of the tissues. There occur in medical practice many cases which withstand the efforts of the best directed treatment, but immediately begin to yield when change of place and scene is resorted to. It is not impossible that the benefit thus derived is frequently owing as much to the supply of some alimentary principle in which the body was formerly deficient, as to the bracing effects of a new air; indeed there are cases in which a change of air may be of less consequence than a change merely of the water which is drunk or used in cooking. Upon the same principle may be explained the appearance of scurvy in penitentiaries where the food was perfectly suitable if used for a short time only, but where its continued use was followed by disease. When the health of prisoners is affected without any apparent external cause, a change of diet is generally followed by an immediate improvement in their condition. The cause of scurvy is evidently diseased nutrition, arising from the non-assimilation of some principle essential to health and the continuance of life, but which either is wanting in the food, or is prevented from being duly assimilated, by peculiar circumstances unfavourable to healthy action. Some physicians look for the deficient principle in the vegetable acids, and in support of their opinion refer to the speedy recovery of cases occurring on shipboard, when the crews are supplied with lemon-juice or fresh vegetables. It is more probable, however, that the vegetable acids act by aiding in the proper assimilation of the food, and not by supplying a deficient principle. Others are disposed to ascribe the disease to a deficiency of potash in the system; and bring forward in confirmation of this view, cases which were benefited by the exhibition of the nitrate of that alkali. Liebig, again, ascribes the disease to a deficient supply of inorganic matter, caused by the long-continued use of salt meat, which has been deprived of its soluble salts by the brine. But if the absence of these salts were the cause, on what principle could we explain the beneficial action of the pure vegetable acids? Other physiologists believe that scurvy may arise from the deficiency of any one principle, the presence of which is essential to the well-being of the economy. Thus, Dr Christison ascribed the occurrence of

* Experiments, &c., p. 105.

† Annales de Chimie et de Physique. Tome xvi., 1846, p. 486, *et seq*

a number of cases in the Perth Penitentiary to the deficiency of nitrogenous food, consequent on the withdrawal of a supply of milk from the prisoners. Influenced by this view, that able physician ordered the supply of milk to be restored, and the disease quickly disappeared. That the external circumstances of an individual also have an influence on the development of the malady, is plain from the fact, that the number of the prisoners attacked, stood in an increasing relation to the period of their confinement.*

Subjected to the influence of the gastric juice, animal food becomes so entirely converted into chyme, as to present no trace of its original organization on its expulsion from the stomach. But with fibrous vegetable aliments it is otherwise. On their expulsion from the stomach, they are in general found to be only partially changed, and to retain some trace at least of their distinguishing structure, which, indeed, they often do not lose entirely till they have advanced a considerable way in their progress through the intestinal canal, and have there undergone what may with propriety be called the completing process of *intestinal digestion*. In cases of dyspepsia, fruits and fresh vegetable aliments often pass through the bowels very little changed.

Instances are very rare, in which, as in Alexis St Martin, the process of healthy stomach-digestion is laid open to our view; but those in which some of the changes produced in the food as it passes through the intestinal canal may be examined are less unfrequent. There occasionally occur in the intestines themselves, obstructions which, by interrupting the passage of their contents, would speedily prove fatal, if Nature did not in some instances avert the danger by forming a new and direct outlet, by means of which the residue of the food continues to escape through the coats of the bowel to the surface of the body, either for the remainder of life, or till the natural channel be restored. As these openings occur sometimes higher up, and at other times lower down, it is obvious that a good deal of information may be obtained by observing and comparing the different appearances which the intestinal contents present on their escape, according to the portion of the bowel in which the opening is situated. The late Baron Dupuytren had at various times under his care, patients in whom an opening from the intestine had taken place at different distances from the stomach, and through which the intestinal contents readily escaped. On giving several kinds of food at one meal, he remarked that they presented themselves at the wound in the *inverse* order of their digestibility. Thus, fresh vegetables always made their appearance first, still retaining much of their peculiar structure; while animal substances either did not appear at all, or were so much altered in appearance as scarcely to be recognised. In the natural evacuations, however, the vegetable structure was generally imperceptible; so that a considerable change must have taken place on it as it advanced through the bowels, after passing the seat of the wound. M. Londe, the well-known writer on Hygiene, has availed himself more extensively and carefully of the occurrence of such opportunities of increasing our knowledge than any other observer with whom I am acquainted, and it will be not less an act of justice to him than advantageous to the reader, to direct attention to his results. M. Londe's conclusions, indeed, may be relied upon with considerable confidence, as their accuracy is confirmed, not only by their accordance with Dr Beaumont's observations, but by the direct and concurrent testimony of Professor Lallemand of Montpellier, and Mons. Bouillaud of Paris, who also investigated the subject with care and success. The propositions in which M. Londe has embodied his results are the following:—

"1. Animal food appeases hunger more completely, and for a longer time, than vegetable food. This fact

* For an able and interesting article on Scurvy, we refer to the fourth number of the British and Foreign Medico-Chirurgical Review.

has been observed in all times and places, and no proofs are required to substantiate its truth."

"2. Animal substances are better fitted for being acted upon by the digestive organs than vegetable aliments; in other words, they are better calculated than vegetables to excite the assimilating powers of the stomach. The following is a proof. The residue which one of my patients, Madame Laf****, evacuated by the artificial opening of the bowel, was such, when she had eaten chicken or cutlets, that it was impossible for me to find in it any thing analogous to the original substance. On the contrary, when she had eaten spinage, herb-soup, or rich soup with carrots, I recognised the different vegetables on their escape by the opening, so essentially unaltered, that both the patient and myself could easily distinguish the spinage from the other herbs which the soup contained. Comparative anatomy, indeed, seems to confirm this proposition, as Nature has multiplied and enlarged the digestive organs of herbivorous far beyond those of carnivorous animals. This fact alone ought to have excited a suspicion that the leguminous vegetables are converted into chyle with greater difficulty, and are more refractory to the digestive organs, than animal food."

"3. Animal substances remain longer in the digestive tube than vegetables. The proof is, that, in my patients, salads, prunes, apples, and spinage, always appeared at the wound at the end of an hour, while the animal food never reached it in less than three hours." At first sight the reader may imagine the second and third propositions to be at variance, but they are not so in reality. Vegetable substances leave the stomach sooner than animal, but then they leave it only *imperfectly digested*. Animal food remains longer in the stomach, but leaves it *completely converted into chyme*.

"4. Both animal and vegetable aliments remain in the digestive tube longer in proportion as they contain more nutritive juices, and as the state of that tube enables it to extract a larger quantity of these juices. The proof is the fact just mentioned, that animal aliments remain longer than vegetable. Other proofs are, that several times I gave Madame Laf**** a portion of vermicelli, with water and butter, and also panada; neither of which ever arrived at the wound in less than two hours, and then in a state not recognisable. We have seen, however, that prunes and salads appeared at the end of one hour, very little changed, and that hunger soon returned. Again, the residue of boiled beef arrived at the external opening sooner than that of meat done on the gridiron. Another fact is, that during five days I prescribed to one of my patients, at each meal, either a beefsteak, a cutlet, or the wing of a fowl, but always added either prunes, spinage, or salad. In this case, the vegetable matter uniformly made its exit about an hour after, while the animal food remained, and, after undergoing a complete change, was expelled by the natural outlet. The same thing occurred when fat carrot-soup was given. The carrots alone appeared at the wound, while the animal soup and the bread remained in the intestine. It seems as if the digestive canal, anxious to get rid of the vegetables, from which it could extract nothing, and constantly contracting to drive them away, took the opportunity which the accidental hole afforded of expelling them altogether; while it retained, by a sort of predilection or elective attraction, the animal matter which could repay the expense of its labour." Precisely similar results were obtained by Dr Beaumont in his experiments on the relative digestibility of animal and vegetable food in the stomach of St Martin.

"5. It is probable that the use of aliments which are not easily assimilated, develops the power of the muscular coat of the stomach, as it contracts incessantly to transmit them to the intestine; and it is probable that the same class of aliments leaves the mucous coat in a state of inaction. On the contrary, the use of a diet composed chiefly of substances in which

the nutritive principles are very concentrated, excites strongly the action of the mucous membrane, and gives little scope to the muscular coat. These results, however, are only inferential, and cannot be the subjects of observation."

"6. With regard to the influence which the cohesion of alimentary substances has on their manner of acting, I have observed that, the quantity of nutritive juices being equal, the aliment which has least cohesion traverses the digestive canal most rapidly. In proof of this, I have frequently given, by spoonfuls, eggs imperfectly boiled, and without bread, to the patients above referred to, and the residue was evacuated by the wound in one hour and three-quarters after the eggs were eaten. Hard-boiled eggs, on the contrary, were always much longer of arriving at the orifice. When, on the other hand, any two aliments contain very unequal proportions of nutritive matter, the influence of cohesion becomes scarcely perceptible, and that which is most nutritive remains longest in the digestive canal, even when its cohesion is very small. For example, when stewed or raw fruits, or boiled vegetables, such as carrots or turnips, were given, they arrived at the orifice in one hour; whereas the residue of strong, concentrated soup, in which there was no cohesion, did not reach it till two hours, or nearly three hours when bread was added."*

"7. The alteration which the food undergoes in the alimentary canal, bears a relation also to the wants of the other organs—a fact which requires to be kept in mind, otherwise the results obtained will occasionally seem to be opposed to those already enumerated. For example, after having subjected one of my patients for several days to a strict and severe regimen, I gave him various vegetable aliments in small quantity, and all of them appeared greatly altered. I gave even a salad *à la scarole* without bread, and, in one hour afterwards, a yellow residue of a creamy consistence began to flow from the wound, but not a trace of the salad could be detected in it. As this experiment was one of the first which I made, I concluded, contrary to the opinion of M. Lallemand, that herbaceous vegetables are entirely changed by the digestive organs; but I had soon occasion to recognise both my own error and the accuracy of the results presented by that admirable observer.

"8. When the wants of the organism are not urgent, the digestion or alteration of substances which are difficult of assimilation, such as carrots, fruits, leeks, and many other vegetable aliments, commences only in the *ileum*. I have always found these substances resist the action of the gastric juice and mucous secretions, as well as that of the pancreatic and biliary secretions." When, however, the system is really in want of nourishment, digestion, as already noticed, begins sooner and proceeds faster.

"9. Cookery acts by diminishing the cohesion of some kinds of food, and increasing that of others. It acts also in modifying their smell and taste, which might otherwise prove repugnant to the stomach, and paralyse its action. Cookery also deprives some elements of certain soluble bitter, acrid, or poisonous properties, which might be injurious to the stomach, and even to life. With respect to the stimulating or sedative properties which cookery imparts to food, it may be remarked, that when stimulants are added, digestion is more rapid, and a new vigour is more quickly diffused through all the body. When sedative properties are given to the food, it may either not stimulate sufficiently to be digested at all, or, if it is digested, it may lower the tone of all the functions. In general, the least cooked aliments are those which quicken vital action the least.

"10. The spontaneous alteration which alimentary substances undergo is, within due limits, a very efficacious means of increasing their digestibility;

* These facts are easily explained by the fact that the gastric juice exerts comparatively little influence on vegetables, whereas its continued action is necessary for the digestion of animal substances.

but it renders them, at the same time, somewhat less nutritive. This spontaneous alteration acts in two ways. It first very evidently disunites their principles and impairs their cohesion, and afterwards develops stimulant properties in the nutritive matter. It is on this principle that, to render meat tender and digestible, we allow it to undergo the first stage towards decomposition. For the same reason, we allow bread to ferment. In like manner, to render cheese more stimulating, and to convert it into a digestive seasoning, we allow it to acquire a high degree of alkalescence."*

I have already mentioned, that, in the present state of our knowledge, we can derive but little dietetic aid from any classification based on the elementary chemical composition of alimentary substances. All the varieties of animal food, for example, are composed of nearly the same proportions of the same chemical elements, viz., *carbon*, *hydrogen*, *oxygen*, and *nitrogen*; to which, in certain structures, phosphorus, sulphur, iron, and some earthy salts, are added in small quantity.† But we cannot infer what the dietetic qualities of any particular kind are, merely from knowing which of these elements predominates in its composition. To render this more intelligible, I may add that *fibrin*, which constitutes the principal part of flesh or muscle, *albumen*, which forms the white of eggs, *gelatine*, so well known in the forms of jelly and glue, and *casein*, or curd of milk, possess very different dietetic and other properties, and yet are all composed of nearly the same proportions of carbon, oxygen, hydrogen, and nitrogen, or, in other words, of pure charcoal and three kinds of air or gas, the different modes of atomic combination of which give rise to the distinctive properties of the compounds. The value of an article of diet depends, in a great measure, on the facility of its digestion, and this we can learn from experience only. If leather be submitted to analysis, it will be found to be composed of carbon, nitrogen, hydrogen, and oxygen, in proportions not very different from those found in flesh, and yet there can be no comparison between the nutrient qualities of the two substances. In the same way we find the chemical composition of sugar and woody fibre to be almost identical; the only difference being, that the former contains two atoms of water more than the latter. No one, however, will venture to classify sugar and sawdust as of equal nutrient power. Nor would any one, *à priori*, venture to affirm, that, in certain constitutions, mutton would act as a poison. Yet Dr Prout mentions the case of an individual in whom it always produced vomiting and diarrhœa, though repeatedly disguised for the sake of experiment. It is apparent, therefore, that while we derive much information on the nourishing qualities of alimentary substances from chemical analysis (being certain, for instance, that no substance destitute of nitrogen can nourish the tissues), we cannot adopt chemical composition as a standard of nutrient power. In the present state of science, our chief guide must be experience. As already observed, the digestive organs have undoubtedly the power of forming blood from fibrin, albumen, or casein, indifferently; but they perform this office with more or less facility, and with greater or less excitement of the system in one case than in another, and on these differences are founded the different dietetic properties which they possess. It may seem strange that minute differences of elementary chemical composition should produce so great a difference in the substances formed; but when we consider that the air which we breathe is composed of merely different proportions of the same elements that form nitric acid or *aquafortis*, which corrodes and destroys the living structure, our surprise will cease. The atmosphere consists of 79 parts of nitrogen to 21 of oxygen, while nitric acid is composed of 74 parts of oxygen to 26 of nitrogen; and yet what a difference in their properties!

* Londe, Nouveaux Élémens d'Hygiène, second edition, vol. ii., p. 38.

† See *ante*, Chapter III.

It appears, then, that a knowledge of the *elementary* chemical composition of any animal substance throws very little light on its eligibility as an article of diet. We cannot infer, for instance, that, because fibrin contains more carbon and less oxygen, it must therefore be more stimulating or more nutritious, than gelatine. Experience alone can teach us the qualities of either, and determine their comparative fitness for individual constitutions. But in the case of what are called, in chemical language, the *proximate* or *compound animal principles*, such as *fibrin*, *albumen*, and *gelatine*, which enter, in different proportions, into the composition of every animal tissue, we may derive considerable aid from attention to the degree in which *they* are contained in the food. Each of these principles possesses distinct properties, which may be modified by the presence of the others, but which can still be recognised in all animal parts, more or less easily according to the proportion which it bears to the rest. On this very circumstance, indeed, the best practical classification of the different varieties of animal food is founded; because the general properties of each as an article of diet can be inferred, with tolerable accuracy, from the relation which its predominant principle bears to those which are subordinate.

Acting in accordance with this standard, most writers on dietetics classify all the kinds of animal food into the *fibrinous*, *gelatinous*, and *albuminous*, according as fibrin, gelatine, or albumen, predominates in their composition; and, for ordinary purposes, the arrangement is sufficiently accurate. To these, however, the class of fishes requires to be added.

Fibrinous aliments.—Fibrin is that whitish and tenacious mass which constitutes the thick part of coagulated blood, and which appears almost free from colouring matter in what is called the *buffy coat* or white surface of blood drawn during active inflammation. It is most easily obtained by stirring recently drawn blood with a stick, to which it adheres in proportion as the blood coagulates. From this coagulum the colouring particles may be removed by washing with cold water, the residue being fibrin nearly pure.

Fibrin enters largely into the composition of the muscles, and, indeed, with the addition of some gelatine and albumen, forms their principal ingredient. Hence, all kinds of flesh-meat are essentially fibrinous aliments, and they differ from each other chiefly in the proportion which the fibrin bears to the other ingredients in each. Thus, beef and mutton are more purely fibrinous than veal and lamb; because in the former, and in most animals of mature age, the fibrin exists in larger proportion to the gelatine and albumen than in the latter and in young animals.

In speaking of fibrinous aliments, therefore, we understand muscular tissue as it occurs naturally combined or associated with gelatine and albumen, with various sapid principles, such as osmazome, and with a certain amount of fat. The proportion of fat varies in the flesh of different animals, but is always of such amount as sensibly to modify the nutritive qualities of the meat. It is never wanting even in the leanest meat; and was found by Von Bibra to amount, in the dried flesh of the breast of the ox, to 21·8 per cent.; of the calf, to 10·5; of the sheep, to 9·3; of the roe, to 7·9; of the hare, to 5·3; of the fowl, to 7·0; of the goose, to 8·0; and of the duck, to 9·1.

In this state fibrin is considered the most nutritive of all the alimentary principles; in other words, it contains the largest quantity of nourishment in a given bulk. Fibrinous aliments, accordingly, proceed more slowly through the digestive tube than any others; and during their digestion, they excite the circulation in a higher degree in the vessels of the mucous coat, and cause a more abundant secretion of the fluids required for their solution. They are also more completely dissolved, and leave less residue in the bowels, than most other kinds of food; besides which, from the concentrated nature of their nutritive principles, they are

the most stimulating of all aliments, and those which most excite the production of animal heat, and afford the best support under severe exertion and great exposure to cold or inclement weather. As lean meat contains less carbon than bread does, it has been maintained by some philosophers of the purely chemical school, that the amount of animal heat which meat affords must also be less. This deduction, however, appears to be erroneous.* As just mentioned, the fibrin exists in meat in combination with a variety of principles, and affords in this state a stimulus by which the metamorphoses of the tissues are augmented. It is probable that the fat, which is always present in greater or less quantity, assists considerably in increasing the animal heat; but much, undoubtedly, depends on the vital changes which the stimulus of the meat produces. Besides, it is a question still undecided in physiology, whether the animal heat may not be owing in some measure to the chemical changes, and re-arrangement of particles, which are constantly going on in the body—and not *entirely* to the consumption of carbon. Be this as it may, experience teaches us that fibrin, as it occurs in meat, gives a stimulus and a power of enduring fatigue which cannot be supplied by bread, and which is superior to that afforded by any vegetable protein compound. Meat, says Mulder, may contain less carbon than bread, but it gives to a much greater extent a feeling of energy and life. On this account, the kinds of meat which contain fibrin in its most concentrated form, in combination with fat, constitute the most suitable food in the Arctic Regions; and the quantities in which they are consumed and digested are such as, in our temperate climate, would altogether overpower the system. For the same reason, fibrinous aliments are too exciting to be used with the same freedom in warm climates, or during hot weather, as in cold climates, or during winter.

The kinds of meat in which fibrin principally abounds, are beef, mutton, pork, wild boar, venison, hare, duck, goose, &c. Generally speaking, those meats which are dark in colour contain more fibrin and osmazome than those which are paler. For example, beef contains much more than veal or pork, and goose more than fowls or pheasant. Those kinds, also, the fibres of which cohere most firmly, contain most fibrin.

From what has been stated, it will be evident that the properties of the various kinds of animal food, and their fitness as articles of diet, must depend very much on the proportion which the fibrin bears to their other elements, and on the degree in which the system requires excitement and support. If the individual is subjected to severe exertion or the effects of depressing influences, or is of a soft, sluggish, lymphatic temperament, which stands in need of a healthy stimulus, beef, mutton, and game, in which fibrin abounds, will be very suitable; whereas, if he is naturally of a full, sanguine, and irritable habit of body, and not subjected to much exercise, a diet which contains but a small proportion of fibrin will be most appropriate.

In determining the diet of invalids and convalescents, the same principle of selection may be very usefully applied. From over-anxiety to impart strength, it is a common practice to give a weak and excitable invalid a dinner of beefsteak or roast-meat, because these are known to be more nourishing to a person in robust health than fish or chicken; and surprise is often expressed that, notwithstanding this excellent diet, debility makes progress, and flesh is lost rather than gained. Whereas, if the excitability of such invalids, and the invariable

* Meat loses about 75 per cent. of its weight by desiccation, bread only 45 per cent. The dry residue of the meat contains 52 per cent. of carbon, and dry bread 45 per cent. It is, therefore, the greater amount of water in the beef which reduces its proportion of carbon; and we should bear in mind also, that meat loses water during the process of cooking, the amount being reduced to 60 per cent. by roasting, and to 63 per cent. by boiling, while the relative amount of carbon is of course increased. Moreover, the physiological question is, not how much carbon this or that kind of food *contains*, but *how much, by its digestion, it yields to the blood*. Experience teaches us that carbon swallowed in the form of potatoes, yields much less animal heat than the same amount of carbon swallowed as butcher-meat. Some difficulty may exist as to the explanation, but there can be no doubt of the fact. One cause appears to be, that, in the former case, a larger portion of the carbon passes undigested through the bowels than in the latter.

tendency of strong fibrinous food to increase that excitability, were kept in view, it would speedily be discovered that a gross error had been committed, and that the milder white meats would give more real support, simply from being better fitted to the existing state of the constitution.

The mistaken practice here noticed often arises from confounding together two very different things—digestibility, and fitness as an article of food. The stomach may have no difficulty in digesting a slice of roast-meat, and yet the quantity of stimulating chyme rapidly produced from such diet may be very ill suited to the state of the system at the time; while, on the other hand, a meal of fish or of vegetables, from its slower digestion, and the less stimulating nature of the chyle, may be in every respect the best adapted to the bodily condition. So that, in selecting a proper diet, we must be guided not only by the abstract properties of the articles chosen, but by their relation to the individual constitution and circumstances of the person who is to use them.

As already observed, many meats owe much of their stimulating quality to the fat which is mingled with their fibres, and also to the rapidity with which they are dissolved in the gastric juice. Hence, a meat which is of easy, but, at the same time, of slow digestion, is best adapted to invalids, as the nourishment which it supplies is slowly taken up by the vessels, and introduced so gradually into the system, that it nourishes without exciting. A lean white meat, or white fish, such as haddock, is generally found to agree best with convalescents from inflammatory attacks. On the other hand, fat, from resisting the action of the gastric juice, is peculiarly apt to disagree in weakened states of the system, and sometimes even passes into rancid acidity, producing heartburn and other unpleasant symptoms. Again, if properly digested, it is apt to prove too exciting, and, by raising the animal heat, to produce flushing and feverishness. Cold meat frequently disagrees with feeble stomachs—partly because it affords less stimulus than hot meat to the mucous coat of the stomach, and partly, it is thought, because the fibre of the meat is to some extent shielded from the action of the gastric juice by a coating of congealed fat, which must be melted by the heat of the stomach before digestion can take place.

Gelatinous meats are so called from containing a large proportion of jelly or gelatine. Gelatine is found in the muscles, skin, ligaments, tendons, membranes, and bones; but it abounds most in the flesh of young animals, as in veal or lamb—of which we have a familiar example in the jelly found in cold veal-pies. It is also procured in large quantity from the skin, ligaments, and tendons, especially of young animals. The very name *calf's-foot jelly* indicates this origin; and glue, which is an impure gelatine, is well known to be procured chiefly by boiling scraps of skin till the whole of their gelatine is extracted.

Veal, lamb, fowl, and the young of most animals in which the colourless predominate over the red particles of the blood, constitute the principal varieties of gelatinous meats. They are slower of digestion, less exciting, and less heating, than fibrinous aliments. In weakened constitutions, consequently, they often require to be combined with stimulants, such as spices, to rouse the stomach to their digestion. Without this precaution, they sometimes pass quickly through the intestines almost unchanged, and thus seem to have a laxative effect, when it is only their want of stimulus that is at fault.

Pure gelatine, like every other exclusive aliment, is not in itself permanently nutritious, but becomes so when combined with other nutritive principles. It fills up the system rapidly, but without conferring on it the same enduring vigour as fibrinous meats. From these properties, gelatinous food ought to be preferred where a tendency to excitement exists and requires to be moderated. It is well adapted, for example, to persons of a dry, irritable constitution, to excitable children, and to those whose muscular labour is not so great

as to require more stimulating or nutritious food. For the same reason, it is well adapted to persons recovering from illness, and to whom the red or fibrinous meats would prove too stimulating. Accordingly, chicken-tea, chicken, calf's-foot jelly,* lamb, veal, and other gelatinous aliments, are in common use among invalids; because they are less stimulating, and therefore safer, and less apt to excite a relapse, than beef-tea, roast-beef, or mutton-chop. Indeed, from this very want of stimulus, they are apt to disagree with weak stomachs, unless seasoned with a good deal of spice or vinegar; and hence the practice of sending slices of lemon to table along with them, and also of adding vinegar to their sauces.

Gelatinous meats are peculiarly ill adapted to persons of a sluggish lymphatic constitution, or living in a low damp situation; because in both instances they afford an inadequate stimulus to the circulation. They suit best individuals of a very excitable temperament, or living in a high and dry locality, where support is wanted, and the animal activity requires to be soothed rather than excited. And consequently, in determining their fitness in any individual case, we must be guided entirely by the effect we wish to produce. As a general rule, gelatinous meats promote the action of the bowels more than fibrinous.

The capability of gelatine to renew the muscular tissues, has been denied by many physiologists, principally upon chemical grounds. Their chief reason is, that as gelatine is formed in the system from protein, it is as impossible for protein to be again formed from gelatine, as it is for protein to be formed from urea; both being, according to their views, the product of waste, with this difference only, that urea is at a more advanced stage, having already entirely served its purpose in the economy, while gelatine has to undergo further metamorphoses. As, however, we are not in a position to assert that gelatine is not a compound substance, and may not contain in its composition even protein itself, it would be unwarrantable, in the present state of our knowledge, to limit the nutritive powers of gelatine to the repair of the gelatinous tissues, or to maintain that it can serve only as aliment of respiration. Many experiments have accordingly been made, especially in France, to ascertain whether, in the form of soup made from bones, and eaten along with bread, it is sufficient to constitute the sole or principal nourishment of man. The question is one of great importance in an economical point of view, especially in public institutions, where this kind of aliment has, from its cheapness and supposed wholesomeness, been long in extensive use. The following is an outline of the results obtained by Messrs Edwards and Balzac, whose experiments may be regarded as perhaps the most trustworthy, although they cannot be said to have entirely settled the question.

When dogs were fed upon bread and a soup or solution of gelatine, they gradually became thinner and weaker, till they at last perished when reduced to about one-sixth of their original weight. But if soup made from meat was substituted for that of gelatine, even when the weakness was extreme, recovery speedily followed, and in seven days the dogs regained the whole of their lost weight. This result is the more remarkable, because the only appreciable difference between the two kinds of soup consists in the almost evanescent principles which give flavour and smell to the one, and the absence of which leaves the other comparatively vapid and tasteless. On further examination, M. Edwards found that a very small addition of these apparently insignificant principles sufficed to render gelatine-soup as nutritive as that made entirely from meat. This singular fact was demonstrated, by first feeding a young dog on meat and bread for twenty-three days, and noting the regular increase of its weight during that time. The same dog was then fed for thirty days on gelatine and bread. During this time, it lost

* This substance, being now manufactured in a dry and pure state under the name of "patent gelatine," may be prepared for use in a short time, and with very little trouble, either at sea or on land.

not only all its recently-acquired, but also one-fifth of its original weight. *Two table-spoonfuls* of soup made from *horse-flesh*, containing, of course, the sapid and odorous principles, were then added to fourteen of the gelatine-soup twice a-day, and formed with the bread into a soft paste. This slight addition of four table-spoonfuls in twenty-four hours of the meat-soup, differing from the other only in its sapid and odorous principles, sufficed completely to restore the animal. From the very first meal there was an increase of weight, rapid growth commenced, and in twenty-five days the dog had gained considerably more than its original weight, and was in the enjoyment of vigorous health and strength. These remarkable results shew how great a difference of dietetic properties may arise from even the slightest change of chemical composition, and how necessary it is to have recourse on all occasions to actual observation before deducing general conclusions from apparent analogies of nature.

From the whole of his experiments, M. Edwards infers—"1. That gelatine alone is insufficient for alimentation: 2. That although insufficient, it is not unwholesome: 3. That gelatine contributes to alimentation, and is sufficient to sustain it when it is mixed with a due proportion of other products, which would themselves prove insufficient if given alone: 4. That gelatine, extracted from bones, being identical with that extracted from other parts—and bones being richer in gelatine than other tissues, and able to afford two-thirds of their weight of it—there is an incontestable advantage in making them serve for nutrition in the form of soup, jellies, paste, &c.; always, however, taking care to provide a proper admixture of the other principles in which the gelatine-soup is defective: 5. That, to render gelatine-soup equal in nutritive and digestible qualities to that prepared from meat alone, it is sufficient to *mix one-fourth of meat-soup with three-fourths of gelatine-soup*; and that, in fact, no difference is perceptible between soup thus prepared and that made solely from meat: 6. That, in preparing soup in this way, the great advantage remains, that, while the soup itself is equally nourishing with meat-soup, three-fourths of the meat which would be required for the latter by the common process of making soup, are saved and made useful in another way, as by roasting, &c.: 7. That jellies ought always to be associated with some other principles to render them both nutritive and digestible."*

From these results it may be inferred, that the practice followed in most of our prisons and charitable institutions, of making soup from ox-heads, bones, and the coarser pieces of meat, is judicious as regards both wholesomeness and economy; because, while the bones, especially if broken into fragments, yield a large quantity of nutritious gelatine, the meat attached to them is quite sufficient to supply the required proportion of the more volatile principles. The additional admixture of barley and other vegetables also increases the digestibility and nutritive power of the soup.†

Albuminous aliments, or those in which albumen predominates, are at the same time easily digestible and very nourishing. Albumen itself is found in the blood and various other parts; but it exists nearly pure in the white of eggs. In its liquid state it is colourless and transparent, without smell, and with little taste. It coagulates or becomes firm by boiling or heat, and is more digestible the nearer it approaches to the liquid state. Of this we have a familiar proof in the superior digestibility of soft over hard-boiled eggs.

Albuminous aliments are highly nutritious without being so stimulating as fibrinous meats, and hence are very suitable to excitable nervous constitutions, and during convalescence from diseases characterised by excitement

* Londe, Nouveaux Élémens d'Hygiène, 2d edition, vol. ii., p. 73.

† By referring to page 131, the reader will see that the reasons which have been brought forward to prove gelatine innutritious, might be applied with equal force to albumen or fibrin.

and irritability. For the same reason, they are ill adapted to persons of a lymphatic temperament, or undergoing great exposure or severe labour. In their coagulated state, they are more difficult of digestion, but support the strength better; and hence the frequent and beneficial use of hard-boiled eggs by sportsmen and travellers. I scarcely need add, that, for persons of a bilious or sanguine temperament, engaged in sedentary occupations, and with no outlet for their activity, albuminous and gelatinous are preferable to the more stimulating fibrinous aliments.

Eggs of all kinds constitute the largest class of albuminous aliments. When perfectly fresh, and not overdone, eggs generally agree well even with weak stomachs. When long kept, however, they are often productive of heat and irritation.

Oysters are another of the albuminous articles of diet in very common use. In their fresh state, and eaten along with the salt water contained in their shells, they prove very digestible; but when boiled or stewed, they become tough and resisting, lie long on the stomach, and frequently produce nettle-rash.

Brains owe their digestibility and nutritious quality chiefly to the albumen which they contain; and with many people they are a favourite food.

Those of the albuminous aliments which do not possess highly-stimulant properties (such as eggs and brains) are considered by Londe to be very suitable where the stomach is irritable, and during convalescence, when much nourishment is required. He thinks them well adapted also to old men, females, and literary people. Those of them, again, which, like the oyster, are of a stimulating nature, are suitable enough in cases of impaired digestion, but decidedly hurtful where the mucous membranes are in an irritable state.

In addition to fibrin, gelatine, and albumen, animal substances contain another principle of a very peculiar nature, called *osmazome*. It is this principle which gives to roast and broiled meats their distinguishing taste and dark colour, and probably some portion of their stimulating quality. It is not found at all in the flesh of very young animals, but forms as they advance in age. It is far more abundant in red than in white meat, and indeed constitutes one of the chief distinctions between them; and it is its absence which occasions the want of taste and colour in chicken and veal tea, as compared with beef-tea. Chemically speaking, osmazome does not constitute a well-defined principle, and it is probable that organic chemistry will ere long resolve it into several definite compounds, comprehending perhaps the kreatine and kreatinine of Liebig. Its influence on digestibility and nutrition has already been shewn in the experiments of M. Edwards on the nutritive qualities of gelatine in soup.

There still remains to be noticed another class of animal aliments, in which the fibrinous, gelatinous, and albuminous principles appear in nearly equal proportions, namely, *Fishes*.

Fishes, as remarked by Londe, differ from the mammalia and birds in containing no osmazome; and hence they are well adapted to those who require nourishment without stimulus. Those fishes which are firm and coherent in their texture, as compared with others, are the most difficult of digestion, and contain the largest proportion of fibrin.

Fish, generally speaking, is digested slowly, but without difficulty. From its nourishing without stimulating, it is not well adapted to persons of a lymphatic and inactive constitution, but it is very suitable to those of an energetic or excitable temperament, such as the bilious or nervous-bilious, especially when no great bodily exertion is incurred. For the same reason, it is often a safe aliment during convalescence from illness, where animal food cannot be ventured upon with safety; but in such cases the fat or oily fishes, such as salmon or herring, must be avoided, and choice made of soles, whitings, or haddocks.

The second great division of alimentary substances includes those belonging to the VEGETABLE KINGDOM; but on the properties of these I have little to add to what has already been stated. For practical purposes they may be divided into *farinaceous* and *leguminous;* the former including wheat, rice, and the other kinds of grain, also potato, arrow-root, and sago; and the latter comprising all green or herbaceous vegetables and fruits.

Farinaceous food is easily digested without stimulating the mucous coat of the stomach, and hence it is peculiarly adapted to irritable states of this organ. Londe remarks that farinaceous aliments pass out of the stomach most rapidly, and afford least nourishment, when most fermented. They are, however, the most nutritious of all vegetable substances, and neither excite the circulation nor increase the animal heat. This effect becomes very apparent when we pass at once from an animal to a farinaceous diet. The circulation and all the other functions become lowered; because a large amount of this kind of diet contains, in comparison with animal food, but a small portion of fibrin or albumen—and consequently the blood receives only small and slow additions to its mass, perhaps barely sufficient to sustain its normal quantity. The metamorphoses of the tissues proceed with much less energy, partly because the quantity of protein is comparatively small, and partly because vegetable protein does not possess the same stimulating property as the protein of beef or mutton. It may support the system, and be the best form of protein for individuals of excitable temperaments, but it cannot infuse vigour into a lymphatic constitution. If the food contain too small a proportion of the albuminous principles to supply the waste of the tissues, the body suffers, and its weight diminishes. In cases of inflammation, therefore, the food should contain as small a proportion of the albuminous compounds as possible, in order to reduce the quantity of blood, and thus lower the excitement of the system. Individuals of sedentary habits, also, should use a diet in which the respiratory aliment predominates; for such a diet, while capable of sustaining the normal temperature of the body, does not fill the vessels with that excess of blood which keeps the system ever on the brink of disease. But if, on the other hand, an excess of farinaceous food be consumed, the system is apt to be overloaded with fat—as is frequently the case in warm climates, when much rice is eaten and exercise is neglected. The diet must consequently be regulated according to the circumstances of the individual, especially the amount of exercise and the period of life; it being obvious that a growing youth must require a much larger supply of nutritious food than an adult who has reached his full development. According to the calculations of Dumas and Cahours, a man in health requires daily a supply of from 100 to 120 grammes of dry albuminous food. If we take 120 grammes, or nearly 4 oz. troy, as the probable amount, we find from the following table, given in Dr R. D. Thomson's valuable work, that it would require about 16 oz. of bean-meal to furnish this quantity; 26 oz. of oat-meal, 36 oz. of flour, 48 oz. of rice, or not less than 180 oz. of potatoes. Dr Thomson found, as the result of his analyses, that

	Albuminous Matter. Per Cent.
Bean-meal contains	25·36
Linseed-meal	23·62
Scotch oatmeal	15·61
Semolina	12·81
Canadian flour	11·62
Barley	11·31
Maize	10·93
Essex flour	10·55 to 11·80
East Lothian flour	9·74 to 11·55
Hay	9·71
Malt	8·71
East Indian rice	8·37
Sago	3·33
South Sea arrow-root,	3·21
Tapioca	3·13
Potatoes	2·23
Wheat-starch	2·18
Swedish turnips	1·32*

* In constructing the above Table, the amount of albumen was calculated from the nitrogen found

A glance at this Table will shew the comparative nutritive powers of the various substances mentioned; and we may learn from it one cause of the robust health of the Scottish peasantry, who live principally on oatmeal, an article occupying a high place in the list. It must not be inferred, however, that 16 oz. of bean-meal will keep the system in as good condition as 26 oz. of oatmeal or 36 oz. of flour: albumen, it will be remembered, is not the only thing necessary; a sufficiency of carbon to sustain the animal heat must also be afforded by the food. Sixteen ounces of bean-meal could not supply the requisite amount of respiratory aliment, and the tissues of the body would accordingly be absorbed to supply the deficiency. Hence the necessity of providing food which contains a due mixture of *albuminous or nutritious* and *respiratory* food. The former ought to predominate in the diet of an animal taking much exercise, and the latter in that of one living chiefly in a state of rest.

Fresh vegetables and fruits contain a very large proportion of water in their composition, and hence they are much less nourishing than animal or farinaceous food. But, for this very reason, they are not at all exciting, and may be used with great advantage in inflammatory states of the system, and during hot weather. Even in temperate climates, a due admixture of fresh vegetable food seems to be highly conducive to health, especially during summer. In the Arctic Regions, however, it affords too little stimulus to be used in any quantity, and hence the universal preference, by the natives, of a purely animal diet. In the winter of our own climate, also, the desire for vegetable food is less active than in summer, and hence the greater consumption of meat during the colder season.

The great extent and capacity of the intestinal canal in herbivorous animals, and others living on bulky and innutritious food, have already been noticed, and their reason explained. (See pp. 25, 127.) Perhaps it ought to be added, that an additional reason is the fact that the digestion of vegetable nutriment is not, like that of animal food, completed in the stomach, but in the intestines. On examining the bodies of animals at different intervals from the time of feeding, the fibrous structure of vegetable food is observed to diminish in proportion to the distance from the stomach, and it does not finally disappear till the food is nearly arrived at the end of its course. This is another proof that the digestion of vegetable matter is only partially accomplished in the stomach, and that the aid of the intestinal juices is required for its completion. Delabere Blaine arrives at the same conclusion, from considering the peculiar digestion of the horse. In that animal, the stomach is a simple bag of very moderate size, and yet he can not only drink a gallon or two of water at a time, but eat a much larger quantity of hay or grass than his stomach seems to be capable of containing. Blaine explains this, by stating that, in reality, oats and hay are not long retained in the stomach, and that, after receiving the requisite supply of gastric juice, and undergoing its influence to some extent, they are gradually propelled towards the duodenum, where their digestion is continued, but not completed till long after being subjected to the action of the bile and pancreatic juice, and passing through the remainder of the small intestine. It is owing, he adds, to this speedy evacuation of the stomach, that the horse is less inclined to drowsiness, and less incommoded by active exercise, soon after meals, than almost any other animal.

From the circumstance of herbaceous aliment containing *little nourishment* and *much indigestible matter*, it naturally happens that a larger quantity of refuse remains to be thrown out of the bowels when it constitutes the chief part of the diet, than when animal or farinaceous food, which contains *much nourishment* and *little indi-*

by ultimate analysis. This method, however, can be regarded as giving only approximative results, for nitrogen possibly exists in the above-named substances in other forms than as albumen. If an individual were to dine on baked hair or wool, he would consume a highly nitrogenous meal, but one possessed of no great nutritive powers.

gestible matter, is used. Hence, as a general rule, the bowels act more freely, or are more open, in the former than in the latter case; and hence the common saying, that milk, eggs, jellies, and meat, are *binding*. They have the appearance of being so, chiefly because they are almost wholly absorbed. But as neither the stomach nor the bowels are adapted in structure to very concentrated food, such articles cannot be long used with advantage. Brown and rye bread, and fruits, are in repute for relieving a costive habit of body, and their usefulness is explicable on the same principle. They leave a large residue to be thrown out of the system; and this residue, which forms the natural stimulus of the bowels, excites them to freer action. This effect is probably aided also by the stimulus which the indigestible refuse imparts to the mucous glands, increasing the lubricating secretion, and giving additional facility to the propelling powers.

In the United States of America, an active and numerous sect has of late years sprung up, under the auspices of Sylvester Graham, against the use of animal food in any form or quantity, and in favour of the exclusive use of vegetable aliment and water as the natural food of man. By this sect (as had previously been done, with so extensive and useful results, by the friends of the Temperance cause), societies have been formed, tracts printed, and missionaries sent forth to promulgate the doctrine in question. Numerous examples have also been published by Dr Alcott and others, of restored and improved health, arising from the exclusive use of vegetable food where every other means had failed. But I cannot help thinking that both Dr Alcott and Sylvester Graham have unconsciously argued their cause with too much of a one-sided and exclusive zeal, and have drawn conclusions which a larger and less equivocal experience would disown. There is no doubt that vegetable diet, in proper quantity and of proper quality, may form the basis of the food of a strong and able-bodied peasantry, like the Scottish lowlanders; but it must not be overlooked that, along with the vegetable aliment, a considerable quantity of milk is consumed, which, although allowed by these American writers to constitute a part of their vegetable regimen, is one of the most nourishing articles of animal food. That many American citizens should derive benefit from a change from animal to vegetable diet, will appear natural enough on considering for a moment the habits of the people. They sit down to table exhausted with mental or bodily labour, devour with the utmost rapidity a rich and copious meal, and hurry off to resume business without leaving themselves time for digestion. Is it surprising that, under a continuance of such habits, dyspepsia should so frequently occur? An irritable or even inflammatory state of the stomach is induced, accompanied by a sensation of gnawing or craving, which is mistaken for a return of appetite; and a fresh quantity of stimulating food is thrown into the organ, already suffering from over-excitement. If, when the stomach is in this morbidly excited condition, animal food be renounced, and recourse be had to mild and farinaceous diet, great benefit will undoubtedly ensue. The dyspeptic no longer gulps down his food as if running a race against time; he eats slowly, and, not being tempted to commit excess by the savouriness of the good things placed before him, he ceases to distend his stomach by too copious meals. He experiences a sense of comfort to which he has long been a stranger, and, ascribing his former miserable feelings to the *use*, and not, as he ought to do, to the *abuse*, of animal food, he comes at once to the conclusion that vegetables should form the sole and exclusive diet of man, and that animal food, with the exception perhaps of milk and cheese, should be totally proscribed. The arguments of Mr Graham and Dr Alcott in favour of exclusive vegetable diet, are not based on sound physiological principles; and the broad assertions which they make of the superior strength of vegetable-eating savages

in comparison with civilised Europeans, rest on insufficient evidence, and are not supported by the experience of trustworthy observers. The advocates of vegetable diet take for granted, without hesitation, facts which have never been proved; and when Mr Graham asserts that the inhabitants of the Arctic Regions "would endure the cold still better if they were well trained to a correct vegetable diet,"* he assumes as a fact what is merely a supposition of his own, and is directly at variance with all the evidence we possess. Again, when we are asked to credit, on the authority of captains of American merchantmen, that one of their number "often hired men to labour for him in Russia, which they would do from sixteen to eighteen hours, and find themselves, for eight cents per day (the sun shining there sometimes twenty hours in the day)," and that "they would come on board in the morning with a piece of their black bread weighing about one pound, and a bunch of garlic as big as one's fist, and that this was all their nourishment for the day of sixteen or eighteen hours' labour,"—when we are asked to believe all this, we must be excused for hesitating to receive such statements as bearing value in a physiological discussion. As little can we attach any weight to the additional statements, that these men "were astonishingly powerful and active, and endured severe and protracted labour far beyond any of my men. Some of them were eighty and even ninety years old; and yet these old men would do more work than any of the middle-aged men belonging to my ship. In handling and stowing away iron, and in stowing away hemp with the jack-screw, they exhibited most astonishing power. They were full of agility, vivacity, and even hilarity, —singing as they laboured with all the buoyancy and blithesomeness of youth."† It may, therefore, be fairly objected to Mr Graham, that he grounds his opinions upon data which, it is evident to an unprejudiced eye, will not bear investigation. And the same objection applies with equal force to Dr Alcott. When this gentleman, in support of the superior nourishing qualities of vegetable food, quotes a series of experiments by Dr Geoffroy, from the Memoirs of the Royal Academy for 1730, where it is considered to be proved that the proportion of nourishment afforded by beef is to that of bread as 7 to 33—and when we find that these proportions were ascertained merely by determining *the amount of matter soluble in water*, contained in each—we speedily discover that we have to do with a writer little conversant with sound physiological principles, or the rules of scientific investigation. Dr Alcott, however, does not go quite so far as Dr Geoffroy; he contents himself with saying, that "no careful inquirer can doubt that bread, pease, beans, rice, &c., are twice as nutritious—to say the least—as flesh or fish."* Our reply to this assertion is, that we have no proof of the fact: on the contrary, as fish and flesh are known to contain much more fibrin and albumen than are contained in bread and rice, we have no hesitation in asserting that they are better calculated to repair the waste which the body undergoes in severe labour. Analysis has shewn, that the nitrogen of thoroughly-desiccated bread amounts only to 2·27 per cent., while that of desiccated beef amounts to 14 per cent.; and, accordingly, if the nitrogen be taken as the standard of nutritive power, as representing the protein contained in each, desiccated beef must give six times the amount of nourishment (or, more strictly speaking, of matter repairing muscular waste), which bread can afford. Pease contain a large proportion of albuminous principles, and are therefore more nourishing than bread and rice, which are better calculated for the support of the body when no great exertion is required, or, when exertion is necessary, to form part of the diet along with animal food.

The advocates of the exclusive use of vegetable diet, adduce in its favour a number of statements which, at first

* Lectures on Human Life, vol. ii., p. 279.
† Ibid., p. 209.

* Alcott on Vegetable Diet, p. 115.

sight, appear extremely plausible, but which do not stand the test of severe investigation. For instance, these gentlemen not unfrequently refer to the fact, that herbivorous and graminivorous animals are of a mild and gentle disposition, while the carnivora are noted for their ferocity. The fact cannot be denied; but the conclusion sought to be drawn from it, that the difference is owing to difference of diet, is totally untenable. It is evidently the design of the Creator that the carnivora should live upon flesh, and for this very reason they are endowed with those ferocious qualities which have been erroneously ascribed to the use of animal food. Had the lion and tiger been created with the gentle disposition of the lamb, they would have been unable to provide themselves with food, and their species would speedily have become extinct. It is futile to maintain that they might subsist upon farinaceous or other vegetable diet. The structure of their alimentary organs proves that they could not derive sufficient nourishment from herbaceous plants; and granting, for the sake of argument, that a carnivorous animal might be supported on a farinaceous diet, still the question meets us, By what means could it obtain such aliment? It can neither sow nor reap; and the supply of wild grains would be totally insufficient. Besides, it is a matter of every-day experience that the ferocity of carnivorous animals is *removed* by a full supply of flesh: they are ferocious only when hungry—a remark which is applicable also, though in a minor degree, to many human beings. The temper of an irascible person is wonderfully improved by a comfortable meal of animal food; and every one must have remarked how, on the contrary, a naturally irritable temper becomes more irritable under the influence of fasting, or poor diet. "That temper," says Dr Rush, "must be uncommonly guarded, which is not disturbed by long abstinence from food. One of the worthiest men I ever knew, who made his breakfast his principal meal, was peevish and disagreeable to his friends and family from the time he left his bed till he sat down to his morning repast, after which cheerfulness sparkled in his countenance, and he became the delight of all around him."* Shakspeare finely describes this feature of human nature in the speech of Menenius, by whom the failure of an attempt to appease the enraged and haughty Coriolanus is thus accounted for:—

> "*Menenius.* I'll undertake it:
> I think he'll hear me. Yet, to bite his lip
> And hum at good Cominius, much unhearts me.
> He was not taken well; *he had not dined:*
> The veins unfilled, our blood is cold, and then
> We pout upon the morning, *are unapt*
> *To give or to forgive;* but when we have stuffed
> These pipes, and these conveyances of our blood,
> With wine and feeding, we have suppler souls
> Than in our priest-like fasts. Therefore I'll watch him
> Till he be dieted to my request,
> And then I'll set upon him.
> *Brutus.* You know the very road into his kindness,
> And cannot lose your way."
>
> *Coriolanus*, Act V., Scene I.

Over-feeding may doubtless deteriorate the temper, by giving a morbid stimulus to the brain; but as many, if not far more, instances may be brought forward to shew that deficient supplies produce a like effect. The Hindoos are frequently quoted as a remarkable instance of the effects of diet in producing a mild and inoffensive disposition; but mention is forgotten to be made of the Irish peasantry, whose diet is perhaps as exclusively vegetable, and who are notorious for committing deeds of savage barbarity. The Hindoo lives on vegetable diet, partly from poverty and religious opinion, and partly because it is adapted to the climate in which he lives—the Irish peasant because he cannot provide himself better.

Another argument in favour of an exclusively vegetable diet, has been derived from the fact that monkeys, whose alimentary apparatus is closely allied to that of man, live on nuts and wild fruits. This argument falls to ground when we consider that monkeys are inhabitants of warm climates, and that they do not undergo the labour and fatigue to which man is subjected.

Professor Valentin calculated from experiments, of which his own body

* Medical Inquiries and Observations, by Benjamin Rush, M.D., vol. ii., chap. 1, on "the Influence of Physical Causes upon the Moral Faculty."

was the subject, at a time when its weight was 54 kilogrammes (145 lbs.), that he gave off daily by the lungs about 8¼ ounces of carbon, and about half an ounce of nitrogen by the kidneys. Of course these quantities are liable to change,—increasing with increased weight of body and amount of exercise, and diminishing under contrary circumstances. As long as life continues, the lungs give off carbon, and the kidneys nitrogen, even although no food whatever be supplied; and in this case the carbon and nitrogen must be derived from the decomposition of the tissues of the body itself. To keep the body in health, therefore, *the food must supply at least the above quantities of carbon and nitrogen* in order to protect the body against the action of the oxygen of the inspired air; and it matters little whence these supplies are derived, provided the food be of easy digestion, contain the requisite amount of inorganic principles, *and be adapted to the individual constitution of the consumer*. Animal food contains, in a convenient and concentrated form, the protein compounds, the oleaginous principles in greater or less abundance, and a considerable quantity of those inorganic salts, the presence of which is essential to the well-being of the system. This combination it is, which renders the flesh of animals, or some other form of animal matter, if not an absolute necessary of life, at least (in our climate) an *almost* indispensable article of diet. When milk, butter, cheese, or eggs are eaten, as they are by many who call themselves vegetarians, the person cannot be truly said to live on "vegetable food."

Individuals with capacious chests and largely-developed lungs, support an exclusively vegetable diet better than persons with contracted chests and small lungs; because the former are able to assimilate a much larger quantity of farinaceous substances than the latter, and consequently receive into their system a large supply of the vegetable albuminous compounds which those substances contain. The cases of several distinguished men have been brought forward by the advocates of an exclusively vegetable diet, as proofs of its beneficial effects upon the system; and from these they would have us infer, that vegetable diet is well adapted to sustain alike intellectual and bodily vigour. One of their most important cases is that of Benjamin Franklin. But Franklin did not limit himself, even as a general rule, to vegetable diet, although he lived on it occasionally for months at a time.* Moreover, his bodily frame was well adapted to support a vegetable diet, his chest having been large and capacious, as appears from his bust at Philadelphia, which one of his friends, lately alive, declared to be an exact resemblance of the original.† His expertness as a swimmer, and the ease with which he supported himself in the water,‡ are indeed of themselves sufficient to shew that he must have been endowed with largely developed lungs. But Franklin's own memoirs themselves prove that a vegetable diet is not adapted to the constitution of every one; for, in speaking of a three months' experiment which he and a friend named Keimer made of a diet "in which there entered neither fish, flesh, nor fowl," he says, that although *he* "went on pleasantly, poor Keimer suffered grievously," and was unable any longer to withstand the attraction of the flesh-pots of Egypt.§ The case of the philanthropist Howard has also been cited as evidence in favour of a vegetable diet. But here again we must beware of generalizing too hastily from limited experience. Howard was a man of high nervous temperament. "The first thing," says his biographer, "that struck an observer on acquaintance with Mr Howard, was a stamp of extraordinary vigour and energy on all his movements and expressions. An eye lively and penetrating, strong and prominent features, quick gait, and animated gestures, gave promise of ardour in forming, and vivacity in executing, his designs."‖ With respect to his diet we are told,

* Franklin's Memoirs, vol. i., p. 53. London, 1818.
† Combe's Notes on the United States, vol. i., p. 330.
‡ Memoirs, i., 74.
§ Id., i., 53.
‖ A View of the Character and Public Services of the late John Howard, Esq. By John Aikin, M.D. London, 1792, p. 209.

that he "utterly discarded from it animal foods, and fermented and spirituous drinks; water and the plainest vegetables sufficed him," the potato being a great favourite; while "milk, tea, butter, and fruit, were his luxuries."* We have already endeavoured to shew, that the diet ought to be modified to suit the temperament of the individual; and the reader will have no difficulty in here seeing that Howard's diet was singularly well adapted to a highly excitable constitution, while it would have proved injurious to a person of lymphatic temperament. Another principle which should ever be borne in mind is, that *the food must be proportioned to the waste*. Now, the waste consequent upon intellectual exertion is very different from that caused by bodily labour. The waste of the muscles is great and rapid, that of the nervous tissues small and slow. Hence, the railway labourer would speedily succumb under the use of a diet which would be ample for the support of a philosopher whose labours were confined to the closet. Allusion is sometimes made to Sir Isaac Newton, as another example of the beneficial effects of a vegetable diet; but in his Life by Sir David Brewster, we find only once mention made of his diet, and that at a time when he seems to have been upon strict regimen on account of his health. He was then "extremely temperate in his diet. Though he took a little butcher-meat, yet the principal articles of his food were broth, vegetables, and fruit, of which he always ate very heartily."—(P. 320.) In the absence of farther evidence, the fact that Sir Isaac occasionally suffered from gout, leads us to infer that he did not usually confine himself to a vegetable diet. But, indeed, even such a diet as is described in the passage above quoted, by no means deserves the appellation of "vegetable food."

Enough, we hope, has now been said to prove, that although some constitutions may support an exclusively vegetable diet without injury, it cannot be adopted as a universal or even general practice. Accordingly, in all cases where the vegetable albuminous compounds are not supplied in sufficient abundance, the muscular tissues begin to waste, and recourse must be had to animal food to support the strength of the body. In a recent publication,* Professor Mulder ascribes the decay of the Dutch power from its palmy state, when Van Tromp and De Ruyter swept the English Channel, in a great measure to the introduction of the potato, and its usurpation of the place of food more rich in the albuminous compounds. "It is only," says he, "a vigorous and well nourished body that can contain a vigorous and active spirit." If the food contain too little nutriment in proportion to its bulk, the strength of the system is wasted in digesting it. This is the case with an exclusively potato diet. If, as Mulder calculates, 4½ lbs. of boiled potatoes (that is, in the state in which they are eaten) are necessary to supply the daily waste of carbon, and 26 lbs. are required to yield the protein necessary for the full repair of the tissues, it is obvious that the system must either suffer from deficient nourishment, owing to the stomach being incapable of performing the task laid upon it, or that the greater part of the nervous energy must be used up in digesting. Cobbett's opinion, that the potato is the bane and curse of Ireland, thus appears to be maintainable on true physiological as well as other grounds. It may be well to bear in mind, also, that England is the most flesh-consuming country in Europe, while its mortality is the smallest; the duration of life being about a third longer than in Italy, where macaroni and other farinaceous substances form the staple diet, and where milk, partly from deficiency of pasture, and partly from prejudice, is little used. It would be too broad an assertion to say that diet is the sole cause of this difference of mortality, but we may be allowed to view it as one tending to produce the effect. Levy states, that the French railway-la-

* A View of the Character and Public Services of the late John Howard, Esq. By John Aiken, M.D. pp. 222 and 40.

* Die Ernährung in ihrem Zusammenhange mit dem Volksgeist. Utrecht and Düsseldorf, 1847.

bourers, whose diet was principally vegetable, could not compete with their fellow-labourers from England, whose diet comprised a fair allowance of animal food; but that the working power of the French was much increased, and they were able to earn increased wages, when they adopted, in imitation of the English, a more generous mode of living.

From these considerations it may fairly be concluded, that a mixed diet is most conducive to the health of man, and that animal food becomes hurtful only when used in excess, or prepared in too stimulating a fashion.*

I willingly admit, however, that Mr Graham and Dr Alcott have brought forward a mass of valuable information bearing upon a very important question connected with the welfare of man; and whether they are right or wrong in their leading principle, they deserve the gratitude of the public for their exertions. It is certain that vegetable food might with propriety be used by the middle and richer classes in this country to a greater extent than it is, and that it is really wanted as one of the means of counteracting that tendency to constipation which is now so prevalent among them. A very general prejudice exists against even the moderate use of vegetables, on the supposition that they are indigestible and unwholesome, where, in truth, it is excess in the *quantity* of food eaten that alone is to blame. If the diet be moderate in quantity, and duly adapted to the habits of the individual, a fair proportion of vegetables will be digested without difficulty, and prove more advantageous to the general health than a diet composed exclusively of either animal or vegetable food.

In taking leave of this subject, we must remind the reader that it falls within a department of physiology which has only very recently attracted the attention of investigators, and that consequently much still remains to be done in order to perfect our knowledge. We have endeavoured to avoid, as much as possible, all doubtful points, or at least to limit our statements to what seems to bear the stamp of probability, and to be in accordance with previous experience.

In the next chapter I shall briefly touch upon the adaptation of diet to constitution, age, season, and mode of life; but I cannot now conclude without mentioning that, in preparing some of the preceding observations for the press, I have derived much assistance from the excellent work of M. Londe, already repeatedly referred to, and which I recommend to the professional reader as the best we possess on the general subject of Hygiène. From the valuable Manual of Physiology by Professor Valentin of Berne, also, some highly useful materials have been obtained for the present edition of this work.

* This question is evidently of much importance in relation to progeny. If the parents, confining themselves to an exclusively vegetable diet, receive from it insufficient nutriment, can it be doubted that the constitution of the children will suffer?

CHAPTER XIII.

ADAPTATION OF DIET TO CONSTITUTION, AGE, SEASON, AND MODE OF LIFE.

Food to be adapted to constitution and circumstances—Diet must vary with time of life—Diet in infancy—The mother's milk the best—substitutes for it—Over-feeding a prevalent error—Diet after weaning—Too early use of animal food hurtful—Diet of children in the higher classes too exciting—and productive of scrofula—Mild food best for children—Incessant eating very injurious—Proper diet from childhood to puberty—It ought to be full and nourishing, but not stimulating—Often insufficient in boarding-schools—Scrofulous disease from its deficiency—Nutritious and restorative qualities of cod-liver oil—Diet best adapted for mature age—Regimen powerful in modifying the constitution, mental as well as physical—Farther investigation required.

AFTER the exposition contained in the preceding chapter, it will, I trust, be considered unnecessary to adduce any farther evidence to shew that, in practice, a distinct modification of diet ought to be adopted for every marked variety of constitution; seeing that, unless a proper relation subsists between the qualities of the food and the nature of the system which it is intended to nourish, full advantage cannot be obtained from its use. For exam-

ple, the highly-concentrated and stimulating food which is found necessary for the proper sustenance of the trained pugilist or sportsman, whose muscular frame is in high development and constant exercise, would prove far too exciting to the slender and irritable constitution of a person whose characteristic feature is the predominant activity of the brain and nervous system. In like manner, the generous and stimulating diet which suffices merely to rouse a phlegmatic constitution to ordinary energy, would prove far too nutritive for a person of a florid and sanguine temperament, whose predisposition is already towards inordinate activity.

Viewed in this light, the necessity of adapting the diet and regimen to the individual constitution and mode of life becomes so obvious as to excite surprise that it should ever have been neglected. But, strange to say, although the ancient writers attached much importance to this subject, the relation between diet and constitution, as a practical consideration, has of late been so entirely overlooked, and sound physiological principle has been so little consulted with a view to the proper adaptation of the one to the other, that we are at this moment in possession of very little knowledge of any value regarding it, and a long time must elapse before much more can be supplied. My own observations are not sufficiently matured to warrant my submitting them to the public, and the following imperfect remarks are offered in the hope rather of exciting inquiry than of satisfying the curiosity of the reader.

Where the constitution is of a mixed nature, or a compound of two or more of the temperaments already described, a diet composed of animal and vegetable aliment in nearly equal proportions is, under ordinary circumstances, the best. But if any one temperament predominate, the diet should be modified accordingly. Where, for example, the sanguine constitution prevails—characterised by a florid complexion, great activity, strong action of the heart and bloodvessels, and a consequent liability to diseases of excitement and inflammation—the food should habitually be of a kind calculated rather to soothe than to stimulate. Red meat, spices, wines, and fermented liquors, should be used sparingly; and the principal support should be derived from refreshing soups, fish, fowl, mucilaginous vegetables, acidulous fruits, and diluting drinks. In the case of lymphatic persons, on the other hand—whose circulation is weak and slow, and all whose functions are feeble—the system is benefited by the stimulus of a larger proportion of animal food, especially red meat and game; while vegetables, soups, and much fluid of any kind, prove relaxing and injurious. Aromatics and spices, however, are useful, as is also wine in moderation, and conjoined with adequate exercise.

If, again, the individual present a highly nervous temperament—characterised by delicacy, unusual sensibility to impressions, and great excitability without proportionate strength, such as are often seen in females and in men of genius—care ought to be taken not to make use of a heating or stimulating regimen. White meat, such as fish and fowl, is more suitable than the kinds in ordinary use. Spices are hurtful, while farinaceous and mucilaginous aliments, and ripe fruits, are generally beneficial—always supposing that moderation in quantity is attended to, and that the mode of life is in other respects regular and rational.

Where the dark energetic bilious temperament predominates, and much bodily activity in the open air is enjoyed, greater latitude in the choice of food is admissible than in any other constitution. If, however, strenuous and continued exertion be required, a full supply of animal food becomes indispensable for the due support of the system, and the strength cannot be adequately supported on vegetables alone. In such circumstances, a moderate allowance of wine or other stimulus is borne with less detriment, if not with more advantage, than where the temperament is essentially nervous.

On this subject, however, there is still, as I have said, so much need for inquiry, that I shall for the present only refer the reader to the general principles explained in the preceding chapter, and urge upon physiologists the necessity of rendering our knowledge more complete, by diligent and discriminating observations.

There is no kind of alimentary substance of which it can be said absolutely, that it is always proper for the sustenance of man. To be serviceable, the food must, as we have seen, be adapted, not only to the constitution, but to the age, state of health, and mode of life of the individual, and to the climate and season of the year. The same diet which, administered to an adult, is healthful and nutritious, may prove irritating and injurious to a child; and, in like manner, the stimulating animal diet which in winter is highly grateful to the system of a hard-working unexcitable labourer, may prove utterly destructive of health when indulged in during summer by an inactive and excitable female. It becomes, therefore, an object of deep interest to determine the principal causes, and states of the system, which render modifications of diet necessary.

Among the causes referred to, *the state of the body at different periods of life* should certainly be considered as one of the most influential. The differences observed in the constitution of the same person at different ages, are at least as great as those subsisting between different individuals at the same age. In infancy, the lymphatic and nutritive functions greatly predominate over the muscular; and if the highly animalised food which suits the latter were then freely administered, it would infallibly induce disease, and fail to afford the requisite nourishment. In manhood, again, when muscular activity and nutrition are at their height, the lymphatic system in abeyance, and laborious exertion frequently necessary, the mild food of infancy would be equally misplaced. In advanced age, another change of constitution occurs: the soft tissues of early life have disappeared and the whole frame is dry and wasted —a condition which, in its turn, requires food of a different kind from that fitted for either of the preceding stages.

With regard to the diet during the first two years of life, it would be superfluous to repeat here the exposition which was given in some of the preceding editions of this work; for, in my *Treatise on the Physiological and Moral Management of Infancy*, more recently published, the reader will find the subject discussed in all its requisite details. I may however remark, that even the state of the organs of nutrition at different ages is sufficient to indicate a corresponding modification of diet to be proper for each. In early infancy, for example, when no teeth exist, and the muscles which move the jaws are still small and comparatively powerless, so that mastication is impossible, milk from the mother's breast is manifestly the only food intended by Nature for the child; and, so long as that can be obtained of healthy quality and in sufficient quantity, no other aliment should be substituted in its place.

The appearance of the first incisor teeth, however, is an indication that the digestive organs are now sufficiently developed to admit of small quantities of barley-water, panada, thin arrow-root, or milk and water, being given, two or three times daily, in addition to the nourishment drawn from the mother's breast, if the latter be at all deficient. But great care must be taken neither to exceed in quantity, nor to give the food too rapidly; for otherwise the stomach will become too full, and be weakened by the efforts it is obliged to make. I have already pointed out the importance of attending to this rule; and now add the observation that, in accordance with it, Nature, by arranging that the milk shall flow only by slow degrees, has taken care that, in suckling, the child shall receive its food gradually. The appearance of the teeth indicates a preparation of the digestive functions for more sub-

stantial aliment; and by beginning cautiously the use of small quantities of such simple articles as those above named, and gradually increasing the supply according to the wants of the system, an excellent preparation will be made for the process of weaning, which would otherwise, from its suddenness, be attended with serious risk to both parent and child.

After the infant has been weaned, panada, gruel, thin arrow-root, tapioca, sago, rusk, or crust of bread, may be allowed along with the fresh milk and water and sugar, which should still constitute the principal part of the food; and one or other should be preferred according to its effects. The parent, however, must always bear in mind that sago, arrow-root, and similar farinaceous substances, contain scarcely any of the albuminous compounds; so that if milk do not continue to be freely supplied, the health of the infant will infallibly suffer from deficient nutrition. When farinaceous substances are given in moderate quantity, conjoined with milk, and not too frequently, they generally agree well; but in some delicate children they cause acidity, flatulence, and griping. In this case, milk alone may be given, or a trial made of weak chicken-broth, or beef-tea freed from fat, and thickened with rusk, soft-boiled rice, or arrow-root.

The same kind of diet should be continued till after the appearance of the canine or dog-teeth. When these have fairly protruded, a portion of soft-boiled egg may be given as an introduction to the use of a more extended animal diet. In general, solid animal food should not be allowed in any quantity till all the teeth have appeared, and the digestive powers are fully adequate to its assimilation.

In this respect there are two errors which should equally be avoided. If animal food is given too early, or in too great quantity, the system becomes excited, and diseases of irritation are apt to be produced, which impede nutrition, and lead ultimately to the production of scrofula and other organic changes in the glands and bowels, and frequently also in the brain and lungs. In these instances, the child generally eats heartily, but nevertheless continues thin, and is subject to frequent flushing and irregularity of the bowels, headach, and restlessness. His brain partakes of the general irritability of the system, and peevish impatience takes the place of the placid good-humour natural to healthy childhood. In this state the ordinary diseases of infancy—measles, scarlet fever, and hooping-cough—are often attended with an unusual and dangerous degree of constitutional disturbance; and when inflammation takes place, the necessary depletion is borne with difficulty, and the system does not easily rally.

The consequences now enumerated, and the error from which they spring, are most frequently met with in the middle and higher classes of society. Aware that animal substances contain the largest proportion of nutriment in a given bulk, but ignorant of the relation existing between particular kinds of food and particular states of the system, and which can never be safely overlooked in practice, the fond parent naturally imagines that the more nutritious the food, and the larger the quantity administered, the stronger and healthier will the child become. No suspicion is entertained that strong diet may overpower weak organs, and thus induce the very evils which it is sought to avoid; whereas, by adapting the quality and quantity of the food to the condition of the system, the assimilating powers may be gradually invigorated, and healthy nutrition be completely ensured.

Among the wealthier classes, imperfect nutrition most generally arises from excess in quantity, or a too stimulating quality, of food; but among the lower classes, from deficiency in quantity or quality, added to scantiness of clothing, want of cleanliness, and imperfect ventilation. So far back as the year 1810, Mr Richard Carmichael, a distinguished surgeon of Dublin, pointed out, in a small essay which he then published, the powerful effects of these combined causes

in producing scrofulous disease. He was followed at a later period by Sir James Clark, who, in treating of the prevention of scrofula and consumption in early life, lays great stress on the proper regulation of diet, and shews that, even in families free from all hereditary taint, a morbid condition of the system, extremely favourable to the production of both diseases, is speedily brought about by continued mismanagement of diet; and both the public and the profession are deeply indebted to him for drawing attention to the extensive influence of dyspeptic ailments in paving the way for the future inroads of a deadlier disease. True, it has long been the fashion to ascribe many bodily and mental disorders to bile, indigestion, or the state of the bowels; but the rationale of the result has seldom been perceived, or turned to any good account in improving preventive or remedial treatment. Sir James Clark's treatise, however, presents a remarkable exception, and may be referred to as a most instructive specimen of cautious and discriminating medical inquiry.

But although the premature use of flesh is thus injurious, a certain proportion of it becomes essential to health after the body has been sufficiently developed. The instruments of mastication are now fully adequate to their office, and the stomach is no longer oppressed by the effort of digesting animal food. To make it safe, however, even at that age, ample exercise and exposure to the open air are indispensable. By undue confinement to the house or to school, and deficient exposure to the air, a degree of general delicacy may be kept up which is incompatible with the daily use of a stimulant animal diet. The oxygen inhaled by the lungs is not sufficient for the requisite transformations; and the waste occasioned by bodily action being then too limited to require a copious supply of any very nutritious substances, if these be freely allowed they serve only to oppress the digestive functions, and impair the health.

The prevalent and pernicious custom of tasking the minds and confining the bodies of children for many hours in succession at home and in schools, at a time of life when the growth of the body and the welfare of the system require frequent and playful exercise in the open air, and perfect freedom from care and excitement of mind, is the fruitful source of much future bad health, and is eminently calculated to defeat the object aimed at by parents, namely, the mental excellence of the child. The premature exertion of intellect to which it is stimulated by the constant excitement of emulation and vanity, far from strengthening, tends to impair the health and tone of the brain, and of all the organs depending on it; and hence we rarely perceive the genius of the school manifesting in future years any of the superiority which attracted attention in early life: for the most part, he either sinks below mediocrity, or drags out a painful existence, the victim of indigestion and melancholy. On the other hand, some of the most distinguished men who have ever lived were in childhood remarkable only for health, idleness, and apparent stupidity. The illustrious Newton was, by his own account, an idle and inattentive boy, and "very low in in the school," till he reached twelve years of age; and the young Napoleon himself is described as "having good health, and being in other respects like other boys." Adam Clarke was considered "a grievous dunce" when a boy, and seldom was praised by his father, except for his ability *in rolling large stones*, which his robust frame and good health enabled him to do. Gibbon, Byron, Scott, and Davy, were in like manner undistinguished for precocious genius, and fortunately were allowed to indulge largely in those wholesome bodily exercises, and that freedom of mind, which contributed so much to their future excellence.

Among the many who give great promise in early life, and whose talents are then forced by ill-judged cultivation into precocious maturity, how few live to manhood to reap the reward of their exertions, and how few of those who survive preserve their superiority unimpaired! Tasso was early distin-

guished, and wrote his immortal epic at twenty-two years of age; but his life was miserable and his reason disordered, and he died at fifty-one. Pascal and Kirke White are additional examples of the same result.*

Experience, indeed, amply demonstrates that precocious and excessive activity of intellect and vivacity of feeling are most powerful impediments to healthy and vigorous digestion, and consequently to sufficient nutrition. In early life, therefore, when not only health and comfort, but future usefulness, depend mainly on the completeness and vigour with which the system is developed, the preservation of the digestive organs by suitable diet, exercise, and regimen, should be a primary object of attention with every sensible parent. Even as regards superiority of mind, the healthy development of the body is of essential importance, as the only sure foundation on which mental excellence can be built; because, so long as mind and body are intimately connected with each other, the former must continue to be affected by every change in the condition of the organs on which it depends. We enjoy acuteness of vision by preserving the eye in high health, and exercising it regularly and moderately; and, in like manner, we can obtain and preserve intellectual and moral vigour only by preserving the health of the brain, and exercising it in conformity with its natural constitution.

Instead, then, of feeding the closely-confined and excitable children of the middle and higher classes from early infancy on stimulating animal food, and even giving them wine and fermented liquors, we shall act more in accordance with the laws of Nature by restricting them, during the three or four earliest years of childhood, chiefly to a milk and farinaceous diet, with a small allowance of meat on alternate days; and by seeking to increase their digestive power and bodily vigour by frequent exercise in the open air, before giving them a more solid diet. By these means the development of the body, the keenness of appetite, the tone of digestion, and the desire of, and fitness of the system for, animal food, will increase in regular proportion, and a free supply of that species of aliment will even become necessary to carry on the growth. In short, it must ever be remembered, that strength is to be obtained not from the kind of food which contains most nourishment in itself, but from that which is best adapted to the condition of the digestive organs at the time when is taken it.

Children who are prone to bodily exercise, and live almost entirely in the open air, as many of those of the lower orders do, and who display no unusual sensibility or activity of mind, or, in other words, no unusual irritability of the nervous system, not only bear but require a larger proportion of animal food than their more delicate and sensitive companions. Not only is their digestion more vigorous, but the waste going on in the system is much greater, and the nutritive functions are more active: the need, consequently, for nourishing food, and the desire to procure it,* are propor-

* On this and kindred subjects, the reader will find much valuable information in Dr Brigham's "Remarks on the Influence of Mental Cultivation and Mental Excitement upon Health;" reprinted, with excellent practical Notes, by the late Dr Robert Macnish. 2d edition. Glasgow, 1836. See also Dr Caldwell's "Thoughts on Physical Education," &c., and Dr Sweetser's "Mental Hygiène," already referred to.

* Here, however, as at later periods of life, mischief sometimes arises from people not being sufficiently aware that, in common with other sensations, *appetite may be so far deranged by disease as to give very incorrect and unnatural indications.* It often happens, for example, that a patient shivers and complains of cold, when we know by the thermometer that the heat of the skin is really above instead of below the natural standard. In like manner, in some morbid states of the nervous system a craving is often felt, which impels the patient to eat, but which is not true hunger; and hence, if food be taken, it will be digested with great difficulty. Occasionally, on the other hand, no desire for food is experienced when the system really needs it, and when it would be digested with ease if introduced into the stomach. Esquirol alludes to cases of this description, and I have met with similar examples. Voisin also mentions that, in the Hospital of Incurables in Paris, there are some idiots so low in the scale of intelligence, as to make no attempt to take the food which is placed before them, although they eat and digest readily when fed by others. Sometimes, again, appetite is depraved in quality, and the patient desiderates the most nauseous and repulsive kinds of food, such as earth, chalk, coals, or excrement. There are morbid states, too, in which the appetite is prodigiously increased, and the patient consumes incredible quantities of food,—which, however, are very imperfectly digested. Charles Domery, for instance, when a prisoner of war at Liverpool, consumed, in one day,

tionally increased. Hence it happens that, in the wealthier classes of society, young children suffer most from overfeeding; while in the poorer classes they suffer chiefly from the opposite cause. In both, defective nutrition is the result; but the modes in which it is brought about are very different.

One of the most pernicious habits in which children can be indulged, is that of almost incessant eating. Many mothers encourage it from the facility with which, for a time, the offer of "something nice" procures peace. Even from infancy the child ought to be gradually accustomed to eat only when hungry, and when food is really required. After two years of age, an interval of four hours between meals will rarely be more than enough; and to give biscuit, fruit, or bread, in the mean time, is just subtracting from the digestive power of the stomach. Like other organs, *the stomach requires a period of repose after the labour of digestion;* and accordingly, in the healthy state, the sensation of appetite never returns till it has been for some time empty. To give food sooner, is like making a weary traveller walk on without the refreshment of a halt.

It is a great mistake to suppose that children would not be quiet or contented without such indulgence. On the contrary, they would be healthier and happier were the *opposite* system steadily pursued. The greatest obstacle to be encountered is the ignorance of the nurse or mother, and her want of resources for the entertainment and exercise of the child's bodily and mental faculties. If these be duly attended to, the child will not think of eating till the return of appetite enforces the demand; whereas if it be neglected and left idle, every thing will be carried to its mouth as its only remaining resource against absolute inanity. So true is this, that I should regard that nurse as unfit for her employment, who should complain that her charge, otherwise in good health, is incessantly craving for something to eat. In this respect children are like adults. Give them something to do and to think about, and they will desire meat only when hungry. But leave them idle and listless, and eating will become their chief subject of contemplation.

In a matter so important as the rearing of children, it might be supposed that every mother and nurse would anxiously desire instruction on the nature, functions, and wants of the being committed to their fostering care. And yet it is notorious how rarely either the one or the other possesses any but the crudest notions of the animal economy, or can give reasons for the practices they recommend, or modify them to suit variations of circumstances and constitution. In reality, the wonder is, not that so many children die, but that so many survive their early mismanagement.

From the age of six or seven years up to that of puberty, the animal activity is at its height, growth is in full progress, and the nutritive functions are in their greatest vigour. During this period, a larger proportion of animal food, and a more generous diet, become necessary to the enjoyment of health and strength; but they must still be accompanied by ample exercise and free exposure, otherwise they will tend to clog and impede the functions of life. The teeth and other organs concerned in digestion have now become developed, and fit for the assimilation of a richer aliment, and the rapid growth of the body renders an abundant supply of food indispensable. It is then that the healthy youthful appetite demands quantity as well as quality, and that digestion goes on with an ease and vigour which the dyspep-

four pounds of cow's udder, and ten pounds of raw beef, with two pounds of tallow candles and five bottles of porter; and although allowed the daily rations of ten men he was still not satisfied. Baron Percy speaks of another man, who ate twenty-four pounds of beef in as many hours, and thought nothing of swallowing a dinner prepared for fifteen German boors. I once attended a patient who was afflicted with a similar inordinate craving, and whose only pleasure was in eating. In such cases, no restraint except actual coercion is sufficient to prevent indulgence; but the craving itself is as much the product of disease as the shivering in the beginning of fever, and can no more be removed by reasoning than the sensation of cold can be removed by telling a patient that his skin is thermometrically warm. But these, being cases of disease, do not in any degree militate against the accuracy of the exposition which I have given of the *healthy uses* of appetite.

tic parent contemplates with an envious and regretful eye.

At that age, indeed, the nutritive functions are so predominantly active for the purpose of carrying on growth, and repairing the rapid waste caused by youthful activity, that if the natural craving for exercise in the open air be freely indulged, and due attention be given to the development of the bodily frame, the young may very safely be left to choose for themselves both the quality and quantity of their food. In such circumstances, the natural taste inclines so essentially to the preference of plain substantial nourishment, that there is very little risk of excess being committed. But where the parents are intent only on the intellectual advancement of their children, and accustomed to subject them daily to many successive hours of confinement and study, with only an hour or so of relaxation in the open air, as is too commonly the case both with those educated at home and in boarding-schools, an artificial state of being is induced, which makes the rule no longer applicable, and renders necessary a more careful attention to dietetic regimen.

Among the higher classes of society, the unrestricted use of the most exciting kinds and preparations of animal food, and the daily use of wine, are the means generally resorted to for the removal of the delicacy thus engendered; but when we consider the real state of the case, no remedy can seem more preposterous. The evils to be corrected are imperfect nutrition, and want of strength. Now, the imperfect nutrition is caused, not by deficient food, but by impaired powers of digestion and assimilation; and these suffer only because the lungs are denied the free air, the muscles their necessary exercise, the brain its cheerful recreation, and the circulation the healthy stimulus which these united conditions infallibly produce. Instead, therefore, of oppressing a weakened stomach by administering stronger food than it has the power of digesting, the natural course would be to prescribe at first a milder and less stimulating diet,—to improve the tone of digestion by fulfilling the conditions above referred to,—and then, in proportion as the stomach was strengthened, to adopt a more nourishing diet, suited to the increased efficiency of all the animal functions.

By running counter to this method, and using highly stimulating food improperly, many young people of the wealthier classes incur as much suffering from imperfect nutrition, and the diseases to which it predisposes, as if they were really the victims of an impoverished diet. Sir James Clark, after making some very judicious remarks on the influence of bad digestion in inducing the consumptive constitution of body, expresses himself strongly on the evils of which I have just spoken. "Food in excess," he says, "or of a kind too exciting for the digestive organs, may also induce tubercular cachexia,—a circumstance which is not sufficiently attended to, —I may say, not generally understood, even by medical men; nevertheless, I hold it to be a frequent cause of scrofula, and believe that it produces the same effect on the system as a deficient supply." "The imperfect digestion and assimilation in the one case, and the inadequate nourishment in the other, being equally injurious; the forms and general characters which the disease assumes may differ, but the ultimate result will be the same in both cases. The adaptation of the food, both in quality and quantity, to the age of the individual, as well as to the powers of the digestive organs, is too little considered; and the evil consequences of this neglect are often evident in the children of the wealthy classes of society, who are allowed an unrestricted use of the most exciting kinds of animal food."*

The opposite error, of not providing a sufficiently nourishing diet for the young, is, often from kind but mistaken views, much more prevalent than it ought to be. The late accomplished Dr James Hope "believed that exposure to cold, and inadequate nu-

* Clark on Pulmonary Consumption and Scrofula, p. 230.

trition in childhood, sowed the seeds of the disease which was developed in later years. This opinion was the result of his own medical experience, and of physiological observations on animals, in which tubercular disease may be produced by a similar mode of treatment."* And we read of Warren Hastings, that "he always attributed his smallness of stature to the hard and scanty fare" of a school at Newington, where he was "well taught, but ill fed."† Similar cases are of frequent occurrence, particularly in female boarding-schools, where, as already mentioned (p. 109), the system of diet is often insufficient for due sustenance and growth; and where, consequently, the natural expression of impaired health, if not actual disease, is a marked feature in the aspect of most of the pupils. So defective, indeed, is the common school management in this and other respects, that we have the best authority for considering it as a rare exception for a girl to return home in full health after spending two or three years at an ordinary English boarding-school.‡

It is true that much of this result is owing to excessive confinement, neglect of cheerful exercise, ill-ventilated bed-rooms, and other depressing influences: but to these, that of an insufficient diet is frequently added; and when it does exist, it acts with double force, in consequence of the impaired digestion which seldom fails to ensue where the laws of health are so grievously outraged.

I have seen some striking instances of incurable scrofulous disease, induced by the depressing influence of misfortune added to the want of a sufficient supply of nutritious food. After the mercantile disasters of 1825–6, many cases of this kind occurred, especially in families whose sensitive feelings led them to shrink from public observation, and to suffer the severest privations rather than allow their situation to become known. In these cases, the tone of the general health first became reduced, and then local disease was easily excited by any trivial cause. In one, the structure of the bones and joints became disorganised, and amputation of the limb preserved life, but could not prevent other parts of the osseous system from being attacked. In another, caries of the bones of the foot ensued, but the constitution was so thoroughly tainted that no operation could be performed with even momentary success, and, after much suffering, the patient died. The same causes undermined the health of another member of the same family, and led to his death, from consumption, at an early age.

The attention of English medical practitioners has of late years been strongly directed to the beneficial effects of cod-liver oil in scrofula and consumption, and in feeble states of the system generally. Its value as a remedy in such cases has long been recognised in Germany, but it is only now overcoming the prejudice which has hitherto prevented its general adoption in England. Its beneficial operation, not only in arresting the rapid progress of consumption, but even, in many instances, in restoring comparative health and strength, are evidently due to its alimentary qualities, and not to the fractional quantity of iodine contained in it. For this reason, we may here be allowed to speak of its great nutritive power, which brings it directly within our subject, and affords us a striking instance of the great influence of diet upon health. Numerous observations by different individuals concur in giving support to its claims as a substance of peculiar restorative properties; but we shall purposely confine ourselves to a notice of the cases recorded by Dr Williams of London,* a physician whose long experience and correct judgment entitle his opinion to much weight. These cases are amply sufficient to shew that, even in the most desperate states, the system may rally under the use of cod-liver oil, and that even permanent im-

* Memoir of the late James Hope, M.D., Physician to St George's Hospital, &c. By Mrs Hope. 2d edition, p. 4.

† See Edin. Review, No. 149, p. 163.

‡ Dr Forbes, in Cyclop. of Prac. Med., i., 698, *note*.

* London Medical Journal, vol. i., p. 1, *et seq.*

provement may be produced. According to this physician, 206 cases of consumption out of 234, received from its exhibition marked and unequivocal benefit. The improvement was positive in every stage of the disease, though less marked in the first than in the second and third stages, possibly because, at first, "the patients do not commonly consider themselves sufficiently ill to be under constant medical treatment." In the second stage, "the patients have generally had cough for some months, latterly with mucopurulent or opaque yellowish or greenish expectoration, and have begun to lose flesh, colour, and breath, in such a degree as to excite alarm, and induce them to seek further advice. With many, night-sweats had occasionally occurred; and hæmoptysis (spitting of blood) may have been present at a former period. The effect of the cod-liver oil in most of these cases was very remarkable. Even in a few days the cough was mitigated, the expectoration diminished in quantity and opacity; the night-sweats ceased; the pulse became slower and of better volume; and the appetite, flesh, and strength, were gradually improved." But "the most striking instance of the beneficial operation of cod-liver oil in phthisis is to be found in cases of the third stage,—even those far advanced, where consumption has not only excavated the lungs, but is rapidly wasting the whole body, with copious purulent expectoration, hectic night-sweats, colliquative diarrhœa, and other elements of that destructive process by which, in a few weeks, the finest and fairest of the human family may be sunk in the grave. The power of staying the demon of destruction, sometimes displayed by cod-liver oil, is so marvellous, that I will attempt no general description, but will merely quote from my note-books brief extracts of a few specimen cases, that shall plead for themselves." Dr Williams, accordingly, gives the details of eleven cases which amply confirm the preceding statements. "If the experience of the profession at large," he continues, "should accord with my own, and with that of those who have preceded me in recommending cod-liver oil, our prognosis, with regard to phthisis, must undergo some modification. To what extent this modification may reach, cannot be determined, until such cases as those which I have recorded have been tested by years of time; but even now, when we repeatedly find forms and degrees of disease, that former experience had taught us to be utterly hopeless and speedily fatal, retarded, arrested, nay sometimes even removed and almost obliterated by various processes of restored health, we must pause ere we, in future, pass the terrible sentence of 'no hope' on the consumptive invalid." These wonderful and most encouraging results are undoubtedly, in a great measure, due to the nutritive properties of the cod-liver oil, which, unlike most other oleaginous and fatty substances, is of remarkably easy assimilation, and furnishes to the system a supply of respiratory aliment, more concentrated in its nature than that derived from farinaceous food, and therefore capable of supporting the animal heat with less available pulmonary surface. The ease with which the oil enters into combination with oxygen, protects the albuminous principles of the food and the tissues of the body from the action of the latter;* hence the flesh which is gained is not owing, as has been supposed by some, to the transmutation of the oil into fibrin, but simply to a larger amount of the ordinary food being, as it were, at liberty to nourish the tissues, instead of being consumed as respiratory aliment. Dr Williams ascribes to the great affinity of the oil for oxygen, its beneficial operation in checking the purulent expectoration; as he considers the suppuration to arise from too great a supply of oxygen, which is however intercepted by means of the oxygenation of the oil, so that the formation of the pus globule is prevented. But, be this as it may, there can be no doubt that cod-liver oil owes its beneficial action chiefly to the remarkable facility with which it is as-

* See page 85.

similated, and with which it enters into combination with oxygen. Its use, accordingly, increases the animal heat, producing, in some individuals, the perception of a decided glow over the body, which, in others, is limited to a comfortable feeling of *bien-être*. Indeed it happens occasionally, that those who have been for some time accustomed to its use are so conscious of its beneficial and invigorating effects, that they pine for the return of the hour of taking it. To a certain extent, it bears an analogy to alcohol: both have a great affinity for oxygen, and both increase the animal heat; with this essential difference, however, that alcohol produces an excitement of the nervous system which is followed by a corresponding collapse, while the oil affords a genial stimulus, which gradually diminishes as the oil is consumed in the body, but which is unaccompanied by nervous excitement, and therefore is not followed by reaction. It may be that Dr Williams has taken a too sanguine view of the benefit to be derived from the oil, and has over-estimated its power of permanently arresting the course of consumption; still we have no doubt that further experience will prove it to be a most valuable remedy in many enfeebled states of the system arising from imperfect nutrition.

In regard to *the diet best adapted to different constitutions in mature age*, I have already confessed that I have little new information to offer. In determining the question, several other circumstances besides the mere temperament require to be considered. A more or less laborious mode of life, for example, will require a more or less nutritious diet, whatever the original habit of body may be. In like manner, if any temperament be in excess, and we wish to repress its predominance, the same kind of food which is suitable to it in a lower degree will no longer be applicable. Thus, when the lymphatic constitution is predominant, and our object is to diminish its ascendency, and stimulate the system to greater vigour, a larger proportion of solid nourishing food, combined with increased exercise, will be proper, than if there were no such excess. Where, on the other hand, the nervous or sanguine temperament preponderates, a plainer and less exciting regimen will be necessary, than where the constitutional tendencies are more equally balanced.

The power we possess of modifying the constitution by well-directed regimen is very great, and only requires to be sufficiently investigated to have due importance assigned to it in conducting physical education. It is well displayed in the art of training, where diet and exercise are reduced to a practical science for the attainment of certain results, and with remarkable success. In the hands of a trainer, the breathless and oppressed frame of a person over-burdened with lymph and fat speedily becomes converted into an active, firm, and well-conditioned organism, exhibiting a promptitude of action of both mind and body the very opposite of its former manifestations; and if such a change can be effected, by rigid adherence to rules, in the course of two or three months, we may easily conceive the degree of improvement which would follow the uniform observance of proper regimen and dietetic precepts in ordinary society. In improving the moral and intellectual as well as physical condition of the working-classes, the influence of food, air, and exercise, will soon be discovered to possess a degree of importance of which at present scarcely a suspicion is entertained. They constitute, in fact, the very foundation of a systematic education; and mere intellectual culture will fail to produce its full beneficial results, till the organism by which the mind operates be itself improved by a treatment in harmony with its constitution.

If it be impossible for me to communicate sufficient information to enable each of my readers at once to determine beforehand the kind of diet which is likely to suit him best, it will give him at least some satisfaction to remember that, as explained in Chapter VIII., the fulfilment of the conditions

of healthy digestion is of even greater importance than the selection of the proper kind of food. By observing personally what kind of food agrees best with the stomach and constitution, and at the same time attending to the laws of digestion, the probability of causing mischief by an ill-selected diet will be greatly diminished. When we refrain from eating too much and at unseasonable hours, and are not conscious of any undue oppression or discomfort after our meals, but, on the contrary, feel light or refreshed, and, after a time, ready for renewed exertion, we may rest assured that the food which we have taken is wholesome and suitable to us, whatever be its nature and general effects: Whereas if, without committing any excess or other dietetic error, we feel oppressed, languid, and uneasy, we may be just as certain that our food, whatever its general character for lightness and digestibility, is not wholesome or suitable to us under our present circumstances. So that, with a little care and trouble, we shall rarely be at a loss to discover what we ought to eat and what to avoid. And accordingly, it is notorious that indigestion from a wrong choice of food is induced at least nine times by *wilful* indulgence, for once that it occurs from errors originating in *ignorance* alone. If the proper *quantity* of food be not exceeded, and the other conditions of digestion be carefully fulfilled, no serious consequences will result from any accidental mistake in its selection.

After the full exposition of the laws of digestion given in the previous chapters of this work, it is hardly necessary to add, that, although there are very few articles of diet which a person in health, and leading a sufficiently active life, may not eat with impunity, there are, nevertheless, some which should be preferred, and others which should be avoided, by *those whose digestion is impaired*. Thus, as we have seen, vegetables are, generally speaking, slower of digestion than animal and farinaceous aliments, and consequently, when digestion is feeble, are liable to remain in the bowels till acetous fermentation takes place, and gives rise to acidity and flatulence. Fat and oily meats are nearly in the same predicament, and hence, like vegetables, are unsuitable articles of diet for dyspeptics. Soups and liquid food also are objectionable, both because they are ill adapted for being properly acted upon by the gastric juice and by the muscular fibres of the stomach, and because they afford insufficient nourishment. From the former cause, they frequently impair the digestive functions; and from the latter, they induce diseases of debility which it is difficult to subdue. Daily experience furnishes examples of stomachic disorder from eating soups, especially as preliminary to an otherwise substantial dinner; and the fatal epidemic which prevailed a few years ago in the Milbank Penitentiary, was distinctly ascertained to have been caused partly by an insufficient and too liquid diet. It is common, indeed, to see heartburn and indigestion of recent origin cured simply by giving up soups and vegetables, and diminishing the quantity of liquid taken at breakfast and tea.

When, from the state of health or other causes, chicken-tea, beef-tea, veal-broth, or other kinds of soup, require to be taken, their digestibility will generally be promoted by the addition of bread or rice to give them consistency, and by taking little or no other food along with them. Even vegetables, when eaten alone, are sometimes digested without difficulty, where, if mixed with other substances, they disorder the stomach. Dr Abercrombie mentions a very remarkable instance of this kind in a gentleman who "had been for many years a martyr to stomach-complaints, seldom a day passing in which he did not suffer greatly from pain in his stomach, with flatulency, acidity, and the usual train of dyspeptic symptoms; and, in particular, he could not taste a bit of vegetable without suffering from it severely. He had gone on in this manner for years, when he was seized with complaints in his head, threatening apoplexy, which, after being re-

lieved by the usual means, shewed such a constant tendency to recur that it has been necessary ever since to restrict him to a diet almost entirely of vegetables, and in very moderate quantity. Under this regimen, so different from his former mode of living, he has continued free from any recurrence of the complaints in his head, and has never been known to complain of his stomach."* In this case, however, both the *very moderate quantity* of vegetable food to which the patient restricted himself, and possibly also the gradual adaptation of the gastric juice to the nature of the food, had no small share in the subsequent improvement of his digestion.

Dr Beaumont mentions, as a general conclusion from his experiments on St Martin, that vegetable food is slow of digestion: but it is much to be regretted that he gives the particulars of only one or two trials, which lead to no very important results. In one of these, already mentioned on page 57, St Martin ate "nine ounces of *raw, ripe, sour* apples at 2 o'clock 35 minutes. At 3 o'clock 30 minutes, the stomach was full of fluid and pulp of apples, quite acrid, and *irritating the edges of the aperture, as is always the case when he eats acescent fruits or vegetables.*" In another instance, ten ounces of *raw cabbage* were given, and two hours afterwards not a particle of it was to be found in the stomach; while, on a third occasion, half a pound of *raw cabbage*, cut fine, and macerated in vinegar, disappeared in little more than one hour and a half. We have already stated our reasons for believing that the digestion of cabbage and other herbaceous vegetables takes place chiefly in the intestines, and that hence they often leave the stomach much sooner than aliments whose solution can be effected by the gastric juice alone.† When vegetables are allowed by the medical attendant, great stress is commonly laid upon the necessity of their being thoroughly cooked; and yet, if the act of their leaving the stomach be taken as a proof that digestion has been completed, raw cabbage, according to Dr Beaumont's experiments, is very nearly as digestible as soft-boiled rice or sago! It is strange that Dr Beaumont should not have remarked this anomaly—which he seems not to have done, since he neither attempts to explain it, nor speaks of it as remarkable.

Dr Beaumont's testimony in favour of farinaceous vegetables is, however, more precise and satisfactory. In some of his experiments, St Martin reduced to pulp a full meal of *boiled rice*, seasoned with salt, in a single hour. *Soft custard* and *boiled rich sago*, sweetened with sugar, and taken in quantities of a pint each time, were disposed of with nearly equal dispatch, and "there was no acrimony of the gastric contents, or smarting of the edges of the aperture, during their chymification, as is usual in most vegetable and farinaceous aliments;" on the contrary, the sago "seemed peculiarly grateful to the surface of the stomach, rendering the membrane soft, uniform, and healthy."* In these instances, it ought to be remarked, nothing else was eaten at the same time; so that the stomach was not oppressed by *quantity*.

In early life, when digestion is vigorous, the system excitable, and the habits peculiarly active, a full proportion of herbaceous and farinaceous food is proper and salutary. Morning and evening meals of this description, prepared with milk, or taken along with it, are very useful—animal food being reserved for dinner alone. But as age advances and excitability diminishes, and perhaps also as habits of activity and exposure to the open air are changed, the same proportion of vegetable food can no longer be digested so easily, and therefore ought not to be continued.

Pastry, rich cakes, puddings, and other articles containing much fatty or oily matter, are perhaps the most generally indigestible of all kinds of food, and consequently ought never to

* Abercrombie on Diseases of the Stomach, &c., 1st edit., p. 73.

† See *ante*, p. 134.

* Beaumont's Experiments, &c., p. 267.

be eaten when the tone of the stomach is impaired. There are states, however, in which oily articles seem to agree better than lean. I have seen very fat fried bacon, for example, digested with ease at breakfast, where even a small potato would have disordered the stomach. It would have been difficult to afford an explanation of this fact, had we not seen that the digestion of potato and that of fat are totally different processes, and that, in certain states of the system, the digestion of the one may be easily accomplished, while that of the other is difficult or impossible. Dr Beaumont often remarked, that the presence of bile in the stomach facilitates the digestion of fat and oily aliments; and we have already seen that the normal digestion of fat, which takes place in the duodenum, depends on its forming an emulsion with the bile, or with the bile and pancreatic juice. Dr Beaumont mentions, also, that he never found bile in the stomach, at least during health, except when food of an oily kind had been eaten; and, in accordance with this, I have generally noticed that fried bacon agrees best with what are called "bilious" subjects. Still, however, the quantity must be small, otherwise it will prove injurious. Blondlot rejects altogether the supposition that bile can facilitate the digestion of fat or oily aliments, as the quantity of alkali in it is too small to convert so much oil into a saponaceous compound;* but this difficulty is overcome by supposing that the bile does not enter into chemical combination with the oil, but merely forms with it an emulsion, and thus reduces it to a state of division which renders it capable of being taken up by the lacteals.

Plain well-cooked animal food, not too recently killed, and eaten in moderate quantity with bread, rice, or roasted potatoes, forms one of the most easily digested meals which can be devised for a weak stomach. Sometimes, however, potato induces acidity and flatulence, and should not be used. Venison and most kinds of game are very suitable in the same circumstances.

In some conditions of the system, where considerable irritability prevails, and the mode of life is not sufficiently active, dark and red meat proves too stimulating, although easy of digestion. The same thing happens during recovery from illness; and hence fish, chicken, and other white meats, which excite less and are digested more slowly, are often allowable where beef, mutton, pork, &c., cannot be taken with impunity. For the same reason, white and young meats are the best adapted to the excitable systems of the young.*

It would be easy to fill many pages with disquisitions about the preference due to individual articles of food, were such the purpose which I have in view. But books devoted to this branch of the subject abound, and are already in general circulation; and as I have nothing new to add to what is contained in them, and to the general view given in a preceding chapter, it would be making a needless demand on the patience of the reader merely to repeat what is to be found in so many other works. My object is the exposition of PRACTICAL PRINCIPLES rather than of minute details; and my great aim is to enable every intelligent person to understand, not only what digestion is, but the laws by which it is regulated, so that he may know at once WHY it is for his advantage to adhere to one course of conduct in preference to another in regard to it—WHY, in different situa-

* Blondlot, Traité Analytique de la Digestion, p. 161.

* Liebig has lately called attention to various constituents of flesh, which he thinks may cause differences in the nutrient qualities of different meats. The principal of these substances are kreatine and kreatinine. Kreatine seems to exist in larger quantities in the flesh of wild than of tame animals; but as—

1000 parts of flesh of fowls contain only			3·05 kreat.
1000	—	the horse	— 0·72
1000	—	the ox	— 0·697

it does not seem probable that the influence of this substance in nutrition can be very great. Both kreatine and kreatinine are found in the urine, and hence it is doubtful, indeed, whether they assist in nutrition at all, or are not, like urea, the waste product of the albuminous tissues; and we mention them more for the purpose of shewing that their occurrence has not been overlooked, than from any practical use our doing so can have. The investigation altogether is as yet in a very crude state. (See Liebig on the Chemistry of Food, p. 46.)

tions, diet requires to be modified in order to adapt it to the existing wants of the system—and, lastly, the principles according to which such modifications should be determined. If I have succeeded in the attempt to explain any or all of these principles sufficiently to render them susceptible of practical application by the reader, not only shall I be greatly pleased, but the advantage to him will speedily convince him that I have acted judiciously in forsaking the beaten path, and drawing his attention to rules of still greater importance to his welfare, than those which are most commonly treated of under the title of Dietetics.

As a fit conclusion to this chapter, we shall briefly quote a most instructive example shewing the value of the hygienic rules before inculcated, and the fatal consequences of their habitual neglect. We have already pointed out the bad effects of cold, acting on a debilitated frame (p. 87), and the influence of sufficient or insufficient diet in warding off or bringing on disease (pp. 93 and 103): we have, moreover, endeavoured to shew that the food must be proportioned to the labour which the body is required to undergo; and it will be interesting now, in conclusion, to test, by an appeal to some recently published facts, the value of the precepts which have been laid down.

The "Maison centrale" of Nîmes is a large penitentiary, containing an average population of nearly 1200 convicts, most of them adults—the minimum age being eleven. The chief physician is M. Boileau-Castelneau, who has been connected with the prison for twenty-five years, and who vouches, from his own knowledge, for the truth of the statements we are about to repeat.* The following table shews the number of prisoners, and the number of deaths, during a period of nineteen years; the annual average of the former being 1194, and of the latter 94, or 1 death in 12·70 prisoners.

Years.	Number of Prisoners.	Deaths.	Proportion.
1829	1147	122	1 in 9·40
1830	1212	142	1 ... 8·50
1831	1000	64	1 ... 15·62
1832	1050	72	1 ... 14·58
1833	1049	102	1 ... 9·80
1834	1226	85	1 ... 14·41
1835	1219	107	1 ... 11·34
1836	1288	98	1 ... 12·12
1837	1306	115	1 ... 11·35
1838	1256	102	1 ... 12·32
1839	1272	162	1 ... 7·85
1840	1216	135	1 ... 9·07
1841	1173	97	1 ... 12·06
1842	1224	69	1 ... 17·76
1843	1226	52	1 ... 23·52
1844	1290	56	1 ... 23·88
1845	1328	63	1 ... 19·63
1846	1124	68	1 ... 16·52
1847	1184	85	1 ... 13·57
Mean	1194	94	1 ... 12·70

The average mortality among the inhabitants of the town of Nîmes, of the same age and sex, amounted to 1 in 49·9; consequently the mortality of the prisoners was four times greater than that of the free population. M. Boileau-Castelneau enables us to account for this fearful sacrifice of life, by stating that the wards of the prison were over-crowded and ill-ventilated; that in winter they were insufficiently heated; and that the food of the prisoners was coarse and innutritious, while more labour was exacted of them than their strength was fully adequate to perform. If now we consider that, in addition to these causes of disease, the prisoners were exposed to the tyranny of brutal keepers—that they were frequently loaded with irons, and occasionally severely whipped—we shall not be surprised at the frightful mortality which literally decimated these unfortunate men. It will be observed from the table, that the mortality underwent considerable variation in different years. In 1828 the number of deaths was 81; but as the number of prisoners is not stated, we cannot fix the relative mortality. It may be assumed, however, to have been about 1 in 14. From this number it rose in 1829 to 1 in 9·40, and in 1830 to 1 in 8·50; and fell in the year following to 1 in 15·62. In 1839 it reached 1

* See Annales d'Hygiène Publique, Jan. 1849.

in 7·85, and in 1840, 1 in 9·07; and then gradually diminished, till, in 1844, it fell to 1 in 23·88, the smallest mortality noted. In 1845 it began again to increase, and in 1847 amounted to 1 in 13·57. Having made this survey, we may now ask ourselves, What reason is to be assigned for these variations? Their cause is most clearly pointed out by M. Boileau-Castelneau, and conveys a most instructive lesson. The winter of 1828–9 was, at Nîmes, unusually severe and prolonged. The thermometer, for a month at a time, stood below the freezing point, and repeatedly marked 21° Fahr. In the winter of 1829–30, the thermometer, for 36 days in succession, stood below the freezing point; and during 11 days of this time, the temperature oscillated between 23° and 12°. A thaw of 9 days then took place, followed by a second frost that lasted 10 days, during which the extreme cold was 13° Fahr.

The consequences of this unusually low temperature, acting upon systems debilitated by insufficient food, impure air, and work disproportioned to the strength, became apparent in the increased mortality. Those whose constitutions were most impaired were thus carried off, and there were consequently fewer weaklings left to swell the list of deaths in 1831. M. Boileau-Castelneau assigns no reason for the great mortality of 1833. We pass on, therefore, to 1839 and 1840. The diet provided by the State was at all times insufficient to preserve the convicts in health and strength, taking into account the labour that was required of them; but they had it in their power in some measure to increase the quantity and improve the quality of their diet, by laying out at the canteen the proportion of their earnings which was at their own disposal. But on the 10th of May 1839, a ministerial ordinance was issued, limiting the alimentary articles allowed to be sold at the canteen to potatoes, cheese, and butter. Wine and tobacco, which had previously been allowed, were prohibited. In order fully to appreciate the amount of misery thus entailed upon the prisoners, the reader should be aware that, in the south of France, wine is considered an absolute necessary of life. It is drunk by the poorest of the people, and appears essential to enable them to digest their coarse unstimulating food. Within the town of Nîmes it costs about a penny the litre ($1\frac{3}{4}$ pint); and without the wall, where it is free from duty, the labourer may drink it at a penny the hour. Potatoes, butter, and cheese could not replace its stimulus; and besides, from the south of France containing no pastures, the butter was bad and dear, and the cheese also dear. Hence the pittance at the disposal of the prisoners was more than ever insufficient to supply the deficiency of nutriment. Potatoes, we have seen, constitute a bulky and comparatively innutritious article of diet, ill-adapted for giving support to debilitated constitutions.—The consequences of this ill-advised ordinance speedily became manifest. The mortality in 1839 reached the appalling height of 1 in 7·85; and it continued very high during the following year, notwithstanding the relaxation of the rules—the diet being increased, and the prisoners receiving small supplies of wine and tobacco at exorbitant rates, principally through the connivance of the officials. This continued height of the mortality attacted attention, and an endeavour was now seriously made to ameliorate the condition of the prisoners. The old keepers were removed, and their places supplied by the *Frères des écoles chretiennes*. Moral persuasion was as much as possible substituted for physical restraint, and the diet was improved in quantity and quality. In consequence of these measures the mortality immediately began to decrease, and it reached its lowest point in 1844. But fresh errors were now committed: the *Frères des écoles chretiennes*, disgusted at being thwarted in the plans which they thought it right to follow, gave up their charge, and the old system of hard work and cruel punishments was again introduced. At the same time, the pittance at the disposal of the prisoners was reduced

by a ministerial ordinance to a mere fraction, so that they were again exposed to the evils arising from insufficient food. The natural consequences ensued; the mortality increased so much, that, in 1847, it attained the height of 1 in 13·57. But a promise of better days came at last: in February 1848 the government of Louis-Philippe was overthrown, and one of the first acts of the revolutionary government was to issue an ordinance putting a stop to the convict system of labour as it was then carried on. This act was a reprieve from death to many of the miserable half-famished and over-tasked prisoners of Nîmes. While, during the seven months ending October 31, 1847, the number of deaths had been 44; during the corresponding seven months of 1848, after labour had been abolished, the deaths were only 16. Could stronger evidence be adduced of the necessity of proportioning the quantity of food to the labour required? The human frame, says M. Boileau-Castelneau, is as much a machine, and, in that respect, as much subject to the influence of the physical laws, as the steam-engine itself. If the former be supplied with impure air and insufficient food, and the latter with muddy water and scanty fuel, at first imperfect action, and speedily complete cessation of their functions, will ensue in both. We cannot close our remarks on this most melancholy catalogue of evils without doing M. Boileau-Castelneau the justice to say, that he addressed remonstrance on remonstrance to the French government on the evils to which they so recklessly exposed the prisoners, though unfortunately without success. He now expresses his earnest hope that the ministers of the republic will be more considerate of the welfare of the people confided to their care, than were their predecessors of the monarchy.

Perhaps it may be well to shew, before concluding, that imprisonment, when judiciously administered, is far from being necessarily destructive to health. For this purpose we may cite the recorded experience of the Perth Penitentiary. The average number of prisoners in the year 1847 was 351, exclusive of lunatics; and the mortality only 1—two prisoners, however, having been dismissed on certificate that further imprisonment would endanger life. In order fully to appreciate this result, it must be remembered that 1847 was the year during which influenza prevailed, and that no fewer than 86 prisoners were attacked by that epidemic.* In this prison, however, the wards are large, well ventilated, and sufficiently heated; the food is abundant and of good quality; the labour is not disproportioned to the strength; and daily exercise in the open air is not only permitted, but, if necessary, enforced. While, therefore, in the prison of Nîmes, the laws of health were outraged in every possible way, they were observed in the Perth prison with the greatest care. The results were—in the one case a mortality rivalling that of a fever-hospital; in the other, a state of health considerably above the average of that of the country.

CHAPTER XIV.

ON DRINKS.

Thirst the best guide in taking simple drinks—Thirst increased by diminution of the circulating fluids—The desire for liquids generally an indication of their propriety—Much fluid is hurtful at meals—Most useful three or four hours later—The temperature of drinks is of consequence—Curious fall of temperature in the stomach from cold water—Ices hurtful after dinner—useful in warm weather, when digestion is completed and caution used—Cold water more dangerous than ice when the body is overheated—Tepid drinks safest and most refreshing after perspiration—Kinds of drink—Water safe for every constitution—Danger from salts of lead, lime, and other impurities in water—Wine, spirits, and other fermented liquors too stimulating for general use, but beneficial in certain circumstances—Test of their utility—Reformation effected by Temperance Societies, &c.—Hints for promoting the still greater success of their labours—Spirits not the best means of supporting the temperature of the body—Experience of travellers in the Arctic Regions—Experience of English fowlers—Effects of spirits on the stomach.

On the subject of drinks two questions naturally occur: *When* ought we to drink? and, *What* ought we to

* Ninth Report of the General Board of Directors of Prisons in Scotland.

drink? On both I shall offer a few remarks.

In Chapter II. I endeavoured to shew that the sensation of *thirst* is given for the express purpose of compelling us to take liquids whenever the wants of the system require them, and that, in all ordinary circumstances, we cannot have a better or a safer guide. Such is the general case; but, exposed as we are to numerous deviations from the intentions of Nature in our ways of living, a few precautionary observations may be not without use.

The quantity of fluid separated from the blood and thrown out of the system, in the course of twenty-four hours, by perspiration, exhalation from the lungs, the urinary discharge, and the various other secretions, is very great; and were not the loss as regularly supplied by the ingestion of liquid, either as meat or as drink, the blood would speedily become so thick as to be unfit for circulation. This actually happens in spasmodic cholera, in which the serum or watery portion of the blood passes off through the bowels with such rapidity as to cause the entire suppression of the urinary secretion,—and in which, consequently, the urgency of thirst is almost always excessive. In the healthy state, however, the loss of fluid is never too rapid, unless under severe exertion or exposure to a very high temperature; both being circumstances in which, it is well known, thirst becomes urgent in proportion to the necessities of the frame.

In proof of the sensation of thirst being greatly dependent upon the quantity of fluid circulating in the vessels, Professor Dunglison of Maryland refers to the fact mentioned by Dupuytren, that he "succeeded in allaying the thirst of animals by injecting milk, whey, water, and other fluids, into their veins;" and to Orfila's statement, "that, in his toxicological experiments, he frequently allayed, in this way, the excessive thirst of animals to which he had administered poison, and which were incapable of drinking, owing to the œsophagus having been tied." He found, also, that "the blood of animals was more and more deprived of its watery portions as the abstinence from liquids was more prolonged;"* and hence the greater thirst naturally experienced under such circumstances.

As a general rule, then, the desire for liquids will be a sufficient indication of the propriety of their use; but in gratifying it, we should be careful not to drink so fast as either to distend the stomach beyound proper bounds, or to disturb the progress of digestion by undue dilution too soon after eating. Many persons, from habit rather than thirst, impair the tone of the stomach by drinking largely during or immediately after meals, and thus relaxing the mucous coat, and probably affecting the quality of its secretions. If the gastric juice be greatly diluted by extraneous fluids, it is natural to suppose that its solvent power must be diminished; but whether this explanation be sound or otherwise, the practice of drinking frequently is certainly hurtful, and therefore should be avoided.

Experience proves that a moderate quantity of liquid during a meal is beneficial; and if we drink little at a time, the risk of exceeding the proper limit will be very small. Dyspeptics, however, ought to be on their guard against taking too much, as they are apt to be misled by uneasy sensations in the region of the stomach, which are relieved for the moment, but afterwards aggravated by the free dilution of the food. Those also who live well, and are in the habit of taking wine daily whether the system requires it or not, often fall into the error of excessive indulgence in liquids, to mitigate the thirst and irritability which the unnecessary use of stimulants never fails to induce, especially at night. The continued dilution, however, adds to the mischief, by increasing the debility of the stomach; and, as formerly pointed out, the only

* See Professor Dunglison's Elements of Hygiène, p. 324, a work in which the reader will find a great variety of most useful information on every branch of the subject. His remarks on the different kinds of food and drink are among the best which I have met with.

effectual remedy is to adapt the diet and regimen to the real wants of the constitution. Except in disease, a continually recurring thirst must proceed from mismanagement, and it is to be satisfied by an improved and rational regimen, and not by deluges of fluid, which only weaken the stomach still more, and aggravate the craving they are meant to cure.

The opinion is very prevalent, that mild drinks may be taken with most advantage about three or four hours after a solid meal; and, certainly, the almost universal use of tea or coffee about that time appears to sanction its soundness. Theoretically, too, we might expect this result; for digestion is then nearly over, and the addition of liquid aids the absorption of the food, by favouring the process of endosmosis. Many objections, however, have been made to both tea and coffee as an evening beverage, but most of them seem to me to apply to their undue quantity and strength rather than to their temperate use. When made very strong, or taken in large quantity, especially late in the evening, they not only ruin the stomach, but very seriously derange the health of the brain and nervous system.

The question of drink is of little importance as regards breakfast. During the night, the chief expenditure of the system—by perspiration, urine, and exhalation from the lungs—is of a fluid nature, and hence there is a marked and general preference of fluids as part of our first meal. In this country, accordingly, tea, coffee, and chocolate, are in almost universal use for breakfast, and no other liquid is required merely as drink. If, from the mode of life or other causes, thirst be excited in the forenoon, no valid objection can be urged against its moderate and reasonable gratification.

The *temperature* at which liquids are taken is a matter of perhaps greater consequence than it is usually considered. As regards the teeth, we have already seen that either very cold or very hot substances coming into contact with them are apt to be injurious. As regards the stomach, the same principle holds true; and when we consider the multitude and intricacy of its nervous connexions with other vital organs, we can scarcely be surprised at even sudden death being frequently caused by drinking ice-cold water when the body is weakened by exhaustion and profuse perspiration. Of the various subjects connected with digestion on which Dr Beaumont has thrown light by his experiments on St Martin, this is one of the few which he has omitted to investigate with his usual diligence and accuracy; a circumstance which is the more remarkable, because an incidental observation of his own seems to have been, from its singularity, well calculated to direct his attention to its consideration. On the occasion alluded to, when a gill of water at the temperature of 55° Fahr. was received into the empty stomach, in which the thermometer previously indicated a heat of 99°, Dr Beaumont remarked that it immediately diffused itself over the interior surface, *and brought down the temperature to* 70°, at which it stood for a few minutes, and then began to rise very slowly. *It was not till thirty minutes had elapsed and all the water been for some time absorbed, that the mercury regained its former level of* 99°. This is an important fact, and it is curious that Dr Beaumont did not think of following it up by a regular series of experiments, to ascertain the effects of cold and hot drinks on the progress of digestion and on the general system. It is well known, for example, that a copious draught of cold water, taken in a state of perspiration and fatigue, is often instantly fatal; but its operation has never been satisfactorily explained. The experiment above referred to, however, throws some light upon it; for if a single gill of water at 55° (which is not by any means a low temperature), can in a moment reduce the heat of the stomach by no less than *twenty-nine degrees*, when neither fatigue nor perspiration is present to add to its effect,—the influence of a *large quantity* (such as is usually drunk by harvest-labourers

and others who die of it), at a still lower temperature, must undoubtedly be much more powerful and permanent, especially when the bodily energies and means of resisting the shock are impaired by previous exhausting labour under a burning sun. In these cases, the shock necessarily arising from such a sudden and extensive fall of temperature is greatly increased by the position of the stomach in the very centre of the vital organs, to all of which it is most intimately linked by the numerous nervous connexions given for the purpose of extending the range and direction of its sympathies.

Keeping in mind the great depression of temperature caused by swallowing so small a quantity of cold water, and also the ascertained fact that a heat of about 100° is requisite for healthy digestion, we shall have no difficulty in accounting for the injurious consequences frequently arising from considerable quantities of ice-cream being hastily eaten, as they often are, at the end of a substantial dinner. The immediate effects of the rapid cooling which they occasion in the stomach, are the instantaneous contraction and diminished action of its bloodvessels, the consequent stoppage of the gastric secretion, diminished sensibility of its nerves and muscular fibres, and, lastly, disturbance of the heart and neighbouring vital organs, both by sympathy and by the direct abstraction of their heat. Such, at least, are the consequences which flow from the application of cold to parts exposed to observation, and partially verified by Dr Beaumont in the case of the stomach; and if the analogy holds throughout, as there is every reason to believe, we cannot wonder that the free use of ice-cream at the end of a good dinner or supper should retard and even arrest digestion in a person delicately constituted.

In thus condemning the free use of ices at the end of a substantial meal, I do not, however, mean to say that a few tea-spoonfuls of them, eaten slowly, and allowed to acquire a higher temperature before reaching the stomach, will do permanent injury to a person in health and in the enjoyment of sound digestion. Many eat them in this way and are little the worse; partly because the subsequent reaction is, as in bathing, sufficient to counteract the depressing influence, and partly because persons in vigorous health are able to resist causes of disease from which those who are less robustly constituted suffer severely. My belief, however, is, that the *tendency* of ices, taken in such circumstances, is to produce mischief. As well might it be inferred that, because a healthy person who falls through the ice when skating may possess vigour enough to escape injury from the immersion, a similar immersion would be generally harmless, and even beneficial,—as that all may safely eat ices freely because a certain individual has done so with impunity. Dr Beaumont's experiment with the cold water shews clearly that the effect is to *lower the vital tone* of the stomach; and such being the case, those whose digestion is weak should be careful against impairing it still farther by the use of ices. In some instances, however, they probably help to neutralize the bad effects of hot soup, and other dishes eaten at too high a temperature.

The use of cold or iced water in hot weather and in warm climates, *when digestion is not going on, and there is no exhaustion*, is so far from being necessarily hurtful, that, with proper caution, it may prove both grateful and refreshing. In Italy, accordingly, ice is considered so much a necessary of life in summer, that in Naples and other places the confectioners are punished by a fine if they allow their supply to fall short. In Virginia, too, where, as Professor Dunglison mentions, it was very common a few years ago for the labourers in the harvest-field to be killed by drinking copiously of spring-water while overheated, cases of death have become extremely rare since the custom was introduced of supplying them with ice. When water was taken, it was always swallowed hastily and in large quantity, so that the immediate effect on the

system was greater than could possibly arise from the small quantity of ice which is required for quenching thirst. The very slowness, indeed, with which ice melts, not only prevents much being taken, but causes the water procured from it to reach a higher and safer temperature before it arrives at the stomach.* Hence, when ices are used, the more slowly they are eaten the more refreshing and salubrious will they become, because the less violent will be their action upon the nerves, bloodvessels, and membranes of the stomach. From the close sympathy existing between the stomach and the skin, a single teaspoonful of ice-cream, suddenly swallowed when the body is weak and perspiring, will produce as instantaneous a sense of chill as a pailful of cold water dashed over the surface; and on account of this very power over the vital actions of the stomach, ice has of late been cautiously and beneficially prescribed to subdue inflammation of that organ.

Liquids, such as soup, tea, and coffee, when taken at a very high temperature, are also injurious, but not in the same degree. They relax the mucous membrane and weaken the action of the muscular coat, and in so far tend to impair digestion. The fittest temperature for both solid and liquid food is perhaps about the natural heat of the body, or a little above 100 degrees. Dr Dunglison, however, agreeing with some other physiologists, regards hot fluids as stimulating to the stomach, and therefore conducive to digestion; but he admits that debility is their ultimate effect.

When great thirst has been excited by bodily labour or external heat, it will in general be more effectually as well as safely quenched by drinking moderately of tepid than of cold fluids. A tepid draught—a cup of tea, for example—produces no disturbing action in the stomach, and, being immediately absorbed, supplies the deficiency of liquid without changing the balance of the circulating fluids; thus relieving thirst very much in the same way as Dupuytren did by injecting tepid water into the veins: whereas cold drink, by the suddenness of its shock, disturbs the balance of the circulation, and excites a degree of reaction which increases the original discomfort. If the system is at the same time weakened by fatigue, cold drinks are always injurious.

Of late years, a change in the treatment of horses in this respect has taken place. Formerly, it used to be considered dangerous to give water to a horse in a state of perspiration. Now, however, it is a common practice to allow post and stage-coach horses a little water before their run is completed, however warm they may be: but, in the first place, the quantity allowed is small, and always given before the strength is exhausted; and, in the second place, the excitement of the succeeding exercise prevents any considerable disturbance in the balance of the circulation, and thus ensures the animal's safety. If even the same moderate quantity were given at the end of the stage, and the horse were then allowed to rest, inflammation would almost inevitably result.

The same principle applies to the human frame, and affords an easy explanation of the occasional instances we see of persons *heated* by exertion drinking cold water without injury. If the exertion have been merely sufficient to produce *excitement without fatigue, and heat without debilitating perspiration*, and especially if it be resumed after drinking, little or no harm will ensue. But if exhaustion or fatigue have been induced, and the individual be allowed to drink freely of cold water, and then to rest, the probability of bad effects will be greatly increased. Many accidents result from losing sight of this distinction, and from acting alike in circumstances so essentially different.

On the subject of *the kind of drink* which ought to be taken, a great deal might be said, were it necessary to discuss here the qualities of all the liquors that are in use. But, as my

* Dunglison's Elements of Hygiène, p. 331.

purpose is very different, a few general remarks will be enough.

Water is a safe drink for all constitutions, provided it be resorted to in obedience to the dictates of natural thirst only, and not of habit, and with the precautions already pointed out: but unless the desire for it is felt, there is no occasion for its use during a meal, for the mere purpose of conforming to a general practice. Toast and water, whey, beer, barley-water, aërated and soda water, and other liquids of a similar kind, which are little stronger than pure water, may be used, according to the same general principle, by those who prefer them and find them agreeable to the stomach.

We have already had occasion to mention that there occur at times, in medical practice, cases which, after baffling the best-directed treatment, yield at once to the influence of change of residence; and we then stated our opinion that the benefit thus derived is, in many instances, to be ascribed more to the change of the water which is drunk and used in cooking, than to change of air or scene. This opinion is strongly confirmed by two recent instances of the powerful effects which the habitual use of an impure water may produce upon the body. The town of Wolverton owes its origin to the wants of the London and North-Western Railway, and is supplied with water derived partly from a neighbouring canal, and partly from a well sunk fifteen fathoms deep in a marl soil. In 1841 the inhabitants were supplied wholly by well-water; but it was soon observed that its use gave rise to a singular but unequivocal train of symptoms. The houses subsequently built were supplied with half canal and half well-water; but notwithstanding this arrangement, there were continual complaints, especially from persons newly come, that the water was unhealthy. In the men eruptions broke out over the face, hands, and neck, and the women and children were the subjects of much more distressing symptoms. From 1841 to 1847 a large number of cases were attended by the medical gentlemen of Wolverton and the neighbouring towns; but about the autumn of 1847, the water having become unusually thick, yellowish, and loaded with extraneous vegetable matter, the cases increased so much in number and severity, that advice was sought in the metropolis; and accordingly, during the first half of the year 1848, no fewer than 110 out-patients from Wolverton, suffering from the effects of the water, presented themselves at the Middlesex Hospital. The mild cases were affected with scaly eruptions of the face, neck, arms, and hands, accompanied by general disorder of the system; but in the worst cases, principally those of adult females, there occurred constant and severe frontal headach, dizziness of sight, occasional unconsciousness, impaired memory, loss of appetite, great prostration of strength, and other symptoms of deeply-impaired health. These aggravated symptoms were limited to individuals who made an exclusive use of the well-water—the milder cases occurring in those who used partly well-water and partly canal-water; while those who used canal-water exclusively were altogether exempt. "So singular and uniform," says Mr Corfe, at that time resident medical officer of the Hospital, and by whom these details are recorded,* "were the symptoms of the whole class of patients, that I do not exceed the bounds of truth when I assert, that, if a patient presented herself, and informed me of the street she lived in, I could repeat her ailments almost word for word before I interrogated her." The well-water is slightly alkaline, and, according to the analysis of Dr Ronalds, contains in a gallon 40·44 grains of inorganic matter (consisting chiefly of bi-carbonate of lime, with a trace of magnesia; large proportions of sulphate of soda and chloride of sodium; and smaller quantities of the alkaline carbonates), and 2·34 grains of organic matter. The quantity of foreign ingredients is thus by no means large, although sufficient, when the water is constantly used, to produce very serious disorder of the health.

* See Pharmaceutical Journal, July 1848.

The other instance to which we have alluded is that of Claremont. It is well known that, after the French revolution of February 1848, Louis-Philippe and his family took up their residence at this palace, and that, after some time, several members of the party began to complain of bad health, which was eventually traced to the use of water impregnated with lead. Inspection shewed that the pipes and cisterns through which the house was supplied were literally honey-combed by the action of the water, which thus became the medium of distributing a slow but deadly poison.

There are many instances on record in which diseases affecting large communities were distinctly traced to the action of water on lead. Thus, about the middle of last century, the citizens of Amsterdam suffered extensively and severely from disease, consequent on the substitution of lead for tiles on the roofs of the houses, through which means the rain water, which is principally used in that city for culinary purposes, was rendered poisonous. In 1814, the inhabitants of Tunbridge suffered in a like manner from colic, owing to the town being supplied with water which passed through a course of lead pipes for quarter of a mile; the malady disappeared when iron pipes were substituted. But perhaps one of the most striking examples of the deleterious action of water rendered poisonous by lead, is that related some years ago by Dr Wall of Worcester, and quoted by Dr Christison.* "A family in that town, consisting of the parents and twenty-one children, were constantly liable to stomach and bowel complaints; and eight of the children and both parents died in consequence. Their house being sold after their death, the purchaser found it necessary to repair the pump; because the cylinder and cistern were riddled with holes, and as thin as a sieve. The plumber who renewed it informed Dr Wall that he had repaired it several times before, and in particular had done so not four years before the former occupant died."

* Treatise on Poisons, &c., p. 488.

The lower animals are sometimes exposed to injury from the same cause: thus, the "kennel-lameness" with which the buck-hounds at Windsor were affected in 1843, was proved to have arisen from their being supplied with water impregnated with lead. It is worthy of remark that the solvent action of water upon that metal is greatest when the water is most pure, and hence the peculiar risk of using rain-water preserved in leaden cisterns.

Such cases as those above mentioned shew how important it is, in relation to the health and well-being of a community, to ascertain not only that the water with which a town is supplied is pure in itself, but that it is incapable of acquiring deleterious properties by acting on the pipes through which it is conveyed. It would be easy, did our space permit, to furnish many instructive examples of the injurious effects of water, impure in itself, on the constitution. For instance, travellers are well aware that the water of Paris frequently acts as a powerful purgative on those not accustomed to its use; and some remarkable cases have been recorded in which the death of cattle and horses was clearly owing to their being habitually supplied with impure and tainted water.*

From a valuable report drawn up in the year 1848 by Dr R. D. Thomson, on the well-waters of Glasgow,† it appears that the amount of solid matter (salts, &c.) contained in a gallon of the water from some of the wells, is from four to ten times the quantity found in the river-water used in that city; reaching, in four instances, 99·5, 94·6, 84·4, and 83·3 grains

* It is a popular belief in countries where goitre and cretinism prevail, that these diseases are owing to the use of snow-water by the inhabitants. Scientific research, however, gives no support to this opinion; but M. Grange has lately endeavoured to prove that the diseases in question are limited to those countries which derive their supplies of water from magnesian soils, and that consequently the presence of magnesia in the water is essential to the appearance of the maladies. It would be out of place here to enter upon a discussion of this subject; our object being merely to shew that the source of the water consumed in a city is calculated to exercise a powerful influence upon the health of its inhabitants.

† Journal of Public Health, No. x., August 1848, vol. i., p. 270.

per gallon: and that the impurity increases according to the lowness of situation of the well, the proximity of sewers and churchyards, and similar circumstances; and is greatest when, in consequence of dry weather, the percolation of rain-water is small. The impurities consist of "sulphate of lime, carbonate of lime, chloride of calcium, nitrates, chloride of magnesium, chloride of sodium, and probably alkaline sulphate and phosphate, with some silica and traces of iron and organic matter." In considering the source of the nitric acid, one of the most important of the foreign ingredients, and which occasionally exceeds 3½ grains per gallon, he remarks that as this acid has never been found in water from wells in country places, it cannot be derived from the atmosphere, but must proceed from the excretions of the human beings inhabiting the towns. "Animals throw off from their system a portion of their bodies which requires change, in the form of a soluble substance, *urea*, which, when allowed to remain in the air in contact with water, is converted into carbonate of ammonia (smelling salts). Now, ammonia, even in the laboratory, if we supply it with oxygen, can be converted readily into nitric acid. . . . With regard to the source of the other constituents in the well-waters, it appears sufficiently obvious, that if we can trace one of them to impure sources, the others may also be derived from the same localities. I am therefore of opinion, that the contents of our common sewers, and of the outlets for the discharge of the waste fluids of our dwellings, filter, in a greater or less degree, into the wells of the city, the waters of which, therefore, contain a portion in solution of human excretions."

The practical conclusions drawn by Dr Thomson on this subject are of wide application, and deserve to be quoted entire:—

"We have various grounds," says he, "for drawing conclusions with reference to the influence of substances on health. If a substance is not necessary to the human system, its omission from the food is a judicious, if not an imperative, proceeding. In these wells, sulphate of lime is an abundant constituent, but it is not required by the animal economy; and this form of lime is an objectionable one, upon the ground that it is not very soluble in water. Lime in all forms, when used in excess in the food, is highly objectionable, as it is very frequently the cause of gravel and stone, and enters into the composition of many concretions which gather in the human system. So powerful is its influence, that, when a person has been recovering from this painful disorder, a recurrence of the disease in all its violence has been occasioned by the presence of even a small quantity of lime in the water used to drink. It follows, then, that the less the proportion of lime is in water, the better it is fitted for such cases; but although this disease, in its most aggravated form, is fortunately not common, the deposition of minute concretions of lime is far from being a rare occurrence. In country situations in the lowlands, the wells often contain much lime in solution, and the inhabitants do not appear to be liable to gravel; but they are placed in totally distinct circumstances from the dwellers in a large and populous city. To appreciate this statement, we have only to recollect that the mean duration of life in the country parts of England and Wales is about forty-five years, while in Glasgow it is under thirty years. Hence, as city people are much more exposed to the causes of death, their constitutions are not so robust as the inhabitants of the country; and influences which, in the country, do not apparently exercise any prejudicial effect, may, in the altered circumstances of the town, be highly dangerous. It is certain that calculous diseases are of frequent occurrence in our infirmary; and I am informed by a distinguished surgeon of this city, that many cases come from those parts of Ayrshire where the waters used are impure.

"The fact that nitric acid exists in our wells, affords evidence that foreign matter, from the most impure sources,

has free access into their waters; and although none of these substances are direct poisons, when taken in minute quantities, yet we know that they do not exist in our food, and are rather opposed than favourable to health. The minute nature of an impurity is not, however, calculated to fortify us with security against its possible danger, when we call to mind that an imperceptible portion of small-pox matter on the lancet point, is sufficient to subject to mortality an entire nation."*

With regard to such fermented liquors as porter, ale, spirits, and wine, much care is necessary on the part both of invalids and of healthy persons; because much good or evil may be done by these drinks when properly or improperly administered.

The primary effect of all distilled and fermented liquors is *to stimulate the nervous system and quicken the circulation*. In all conditions, therefore, in which the action of these requires to be increased or supported, they are calculated to be useful; and, on the contrary, where it requires to be soothed and abated, they are sure to be prejudicial. To shew the utility of this principle as a test, I shall notice a few of its applications.

Among the higher classes, it is common to give children an allowance of wine every day from a very early age. To determine the propriety of doing so, let us examine what is then their constitutional state. In infancy and childhood the circulation is rapid and easily excited, and the nervous system is strongly acted upon even by slight external impressions. Hence, slender causes of irritation readily excite febrile and convulsive disorders. The object of the parent, therefore, ought to be, not to stimulate, but rather to *abate*, nervous and vascular action. Wine, accordingly, is not only unnecessary, but *positively detrimental to children*, and it is wrong to accustom them to it. There are individual children, no doubt, who are so imperfectly and sluggishly constituted as to require some stimulus to rouse the system to healthy action, and to whom wine is beneficial as a medicine. But these are exceptions to the general rule, and to them it should be given only under medical sanction.

In youth, the natural tendency of the constitution is still to excitement; and consequently, as a general rule, the stimulus of fermented liquors is injurious. During rapid growth, however, the animal functions are sometimes so enfeebled by the great demands made upon them, that not only a full supply of nourishing food, but also an allowance of wine and malt liquor, is required for a time to sustain their energy. In this case, the beneficial influence of the fermented drinks is indicated by their giving tone to the system without raising the pulse or increasing nervous sensibility; but whenever either of these effects is produced, the employment of such drinks should be partially or wholly discontinued.

In mature age, when digestion is good and the system in full vigour, if the mode of life be not too exhausting, the nervous functions and general circulation are in their best condition, and require no stimulus for their support. The bodily energy is then easily sustained by nutritious food and a regular regimen, and consequently artificial excitement only increases the wasting of the natural strength. Where, however, the system has been long accustomed to the use of wine, it will in general be better to leave it off gradually than to make a sudden change. In old age, when the powers

* This illustration, adduced in favour of a true conclusion, appears to us to be founded upon a false analogy. The matter of small-pox exerts upon the system an influence of a specific kind (analogous, in some measure, to that exerted by leaven on dough), by means of which the quantity of the matter is increased, and its action extended to the whole organism. It is, as it were, planted in the system, where, finding a congenial soil, it takes root, and produces a plentiful crop of pustules, each single pustule containing much more matter than was originally inoculated. But the action produced by inorganic impurities is widely different. Sulphate of lime and chloride of calcium, when taken up by the absorbents, do not propagate themselves, and never give rise to more sulphate of lime and more chloride of calcium. On the contrary, they are speedily expelled through the bowels and kidneys, and produce an injurious effect only when, by long-continued use, they alter the composition of the blood, or act injuriously upon the nervous system. But even in such cases, it is generally sufficient to stop the supply of the salts in order to restore health.

of life begin to fail, moderate stimulus may be used with evident advantage.

If it be said that this doctrine amounts to a virtual prohibition of wine and stimulant liquors, I admit at once, that, where the whole animal functions go on healthfully and energetically without them, their habitual use is, in my opinion, adverse to the continuance of health. But there are many constitutions so inherently defective in energy, as to derive benefit from a moderate daily allowance of wine; and there are many situations in which even the healthiest derive additional security from its occasional use. If, for example, a healthy person be exposed to unusual and continued exertion in the open air, or to the influence of anxious and depressing watchfulness, a moderate quantity of wine along with his food may become the means of warding off actual disease, and enabling him to bear up uninjured, where without it he would have given way. This preservative influence has been so often experienced, that it is impossible to deny its reality; and we refer to the instance of the Nimes prison, quoted above, as a case in point.

While, then, I consider every kind of stimulating liquors as both useless and hurtful, in cases where, without them, the system is healthful and energetic, I can see no reason why their temperate use in circumstances of an opposite nature should be denied. Many weak constitutions and many invalids are benefited by wine, and all that can reasonably be demanded is, that it shall not be abused.

Continued and severe exertion, whether of body or of mind, often exhausts the system so much as to render the temporary use of wine, and even of spirits, not only harmless, but positively beneficial; but in these cases they should be considered as medicines, and care should be taken not to carry the stimulus too far. That, in some circumstances, stimulus is really required, is shewn by the ease with which the system bears its effects. I have known a delicate lady, during recovery from fever, take to the extent of a bottle of madeira in twenty-four hours, without producing the least undue excitement of either the mind or the pulse, but rather the contrary—it soothed the mind and reduced the pulse; and this I take to be in all circumstances the true test of the propriety of using wine or spirits.

The same principle explains the well-known fact that many sportsmen, who, while leading a sedentary life in town, are easily affected by even a small quantity of spirits, yet bear triple the quantity, with apparent impunity, under the influence of inspiriting exercise in a pure mountain air. On resuming their former habits, they are again affected by spirits as readily as before.

As a support to the system in cases which require it, wine is, in general, far preferable to spirits of any description. The former, when seasonably used, communicates a more healthful and permanent tone to the frame; while spirits impart a strong and unnatural stimulus, which is sooner or later followed by collapse and debility —and hence the incessant craving for more when the system has once been accustomed to them. Ardent spirits, therefore, should be used only as a medical remedy. At present, however, this is so far from being the case, that they are resorted to on all occasions, mournful and convivial, as if they were alike a specific against every evil, and an enhancer of every joy. Among the poor, especially, whisky or gin is considered a sovereign remedy for every disease. Even to infants it is administered with a recklessness which savours strongly of barbarism; and, as might be expected, the consequences are deplorable. Among the higher classes, too, brandy and strong stimuli are in more frequent use than they ought to be; and medical men should be on their guard against directly or indirectly encouraging in their patients a practice so utterly destructive to health and happiness. For it is to be feared that, in some instances, the stimulant bitters and anti-spasmodics, so generally had recourse to in indigestion and nervous diseases, have had

an unsuspected share in the formation of a habit of intemperance.

Of late years, great exertions have been made, both in this country and in America, to warn the public against indulging in the use of ardent spirits; and powerful facts and arguments, as well medical as moral, have been adduced to demonstrate the unspeakably greater advantages of temperance. These efforts have been followed with astonishing success, and the good already done is immense. In Ireland, especially, the reformation which was effected in the habits and morals of the people under the total-abstinence system so energetically and eloquently advocated by Father Mathew, was such as almost to surpass belief from its extent and universality, and to be highly gratifying to every philanthropic mind. It is probable, however, that the good thus achieved would have been still greater, and more permanent, if mere abstinence from intoxicating liquors had not been so exclusively inculcated, and if the advocates of reform had concerned themselves more in improving the general character, as the surest road to reformation, and in *providing resources by means of which the reformation, when once effected, might be fully confirmed*. The temperance which is produced by elevation of mind, and an improved state of moral feeling, will be not only much more beneficial in its consequences, but infinitely more proof against temptations, than that which is observed merely in fulfiment of a vow; and unless something be substituted for the enjoyment which is withdrawn, the danger of a relapse will continue to be great. The justice of these remarks has unfortunately been confirmed by the backsliding of many of the Irish into their former intemperate habits. The wide-spread misery which has afflicted their unhappy country may, in this instance, have been the chief cause of the relapse; still we cannot help ascribing much influence to the want of the more deep-seated motives which have just been mentioned. The importance of these is perhaps not sufficiently recognised in the otherwise valuable labours of Temperance Societies: but the institution of reading-rooms accessible to the poor at a trifling expense is an important step in the right direction, and every one must have rejoiced to witness the powerful and successful efforts lately made to provide parks and pleasure-grounds for the recreation of the people in large towns. Those annual or biennial exhibitions of manufactured articles, curiosities, and objects of art, which were commenced a few years ago in the Mechanics' Institutions of Manchester, Liverpool, and Leeds, and have been visited by vast multitudes of work-people and their families, are also worthy of high commendation. Cheap trips by railway or steam-boat to places remarkable for scenery or other interesting features, are another excellent means of promoting, both physically and morally, the cause of temperance; and I doubt not that, ere long, many new sources of recreation to the lower classes will be provided. If to the boundless supplies of cheap and excellent literature that now issue from the press, an efficient system of national education were added, the increase of sobriety, consequent on these and other appliances, would be such as to make posterity look back with surprise or incredulity upon the barbarous intemperance of the present and former times.

Many persons imagine that spirits, taken in moderate quantity, cannot be injurious, *because they feel no immediate bad effects from their use*. But if the fundamental principle which I have advanced be sound, and if all the functions of the system are already vigorously executed *without* the aid of spirits, their use can be followed by only one effect—*morbid excitement;* and it is in vain to contend against this obvious truth. The evil attending their unnecessary use may not be *felt* at the moment, but nevertheless it exists; and for demonstrative proof of the fact, we are again indebted to Dr Beaumont. On examining St Martin's stomach after he had been indulging freely in ardent spirits for several days, Dr Beaumont found its mucous mem-

brane covered with *erythematic* (inflammatory) *and aphthous* (ulcerous) *patches*, the secretions vitiated, and the gastric juice diminished in quantity, viscid, and unhealthy; although St Martin still *complained of nothing*, not even of impaired appetite. Two days later, when the state of matters was aggravated, "*the inner membrane of the stomach was unusually morbid, the erythematic appearance more extensive, the spots more livid than usual: from the surface of some of them exuded small drops of grumous blood; the aphthous patches were larger and more numerous,—the mucous covering thicker than common, and the gastric secretions much more vitiated. The gastric fluids extracted were mixed with a large proportion of thick ropy mucus, and a considerable muco-purulent discharge slightly tinged with blood, resembling the discharge from the bowels in some cases of dysentery.* Notwithstanding this diseased appearance of the stomach, no very essential aberration of its functions was manifested. St Martin complained of no symptoms indicating any general derangement of the system, except an uneasy sensation and a tenderness at the pit of the stomach, and some vertigo, with dimness and yellowness of vision, on stooping down and rising again; had a thin yellowish-brown coat on his tongue, and his countenance was rather sallow; pulse uniform and regular, appetite good; rests quietly, and sleeps as usual." (P. 250.)

I have marked part of this quotation in italics, because it cannot be too attentively considered by those who contend that the stimulus of spirits is not injurious to the stomach or general health, except where the mischief shews itself by palpable external signs. Here we have incontestable proof that disease of the stomach was induced, and going on from bad to worse, in consequence of indulgence in ardent spirits, although no prominent symptom made its appearance, and St Martin was in his general habits a healthy and sober man. And if such be the results of a few days of intemperance in a person of a sound constitution, it is impossible to deny that continued indulgence must be followed by more serious evils, whether these shew themselves from the first by marked external signs or not.

After a few days of low diet and the use of mild diluents, the coats of St Martin's stomach were seen to resume their healthy appearance: the secretions became natural, the gastric juice clear and abundant, and the appetite voracious. Dr Beaumont adds, that, in the course of his experiments, diseased appearances of a similar kind were frequently observed—generally, but not always, after some appreciable cause. "Improper indulgence in eating and drinking has been the most common precursor of these diseased conditions of the coats of the stomach. *The free use of ardent spirits, wine, beer, or any intoxicating liquor, when continued for some days, has invariably produced these morbid changes. Eating voraciously or to excess, swallowing food coarsely masticated or too fast,*" "almost invariably produce similar effects, if repeated a number of times in close succession." (P. 252.) These observations require no comment; their practical bearing must be obvious to all who are willing to perceive it.

Dr Beaumont had also frequent occasion to remark, that, when stomachic disorder, attended with febrile symptoms, was present, the mucous coat of the stomach presented distinct appearances of disease. He frequently saw it, for example, red, irritable, and dry; and on the food touching it, *no gastric juice exuded*, and, consequently, any food taken lay long undigested. But after the diseased action was subdued by regimen and medicine, the gastric juice again flowed readily, and digestion went on as vigorously as before. Even anger and violent mental emotions sometimes produced the appearances just mentioned, and gave rise to temporary indigestion. These observations shew the futility, not to say mischief, of administering food during fever and other diseases by way of supporting the strength, when, from the deficiency of the gastric juice, it cannot be digested, and can only add to the existing irritation. In this state,

however, bland fluids are very suitable; because they allay irritation, and are almost entirely absorbed without requiring to be digested.

The condition of the stomach above described, and the consequent failure and vitiation of the gastric secretion, induced by drinking ardent spirits, and by general intemperance, explain at once the miserable digestion and impaired appetite of the habitual drunkard; and it would be well for those who are in danger of becoming the victims of the habit, were they early impressed with some of these striking and important truths. The facts mentioned by Dr Beaumont bear more particularly upon the *immediate* bad effect of alcoholic liquors upon the system; but there is evidence not less convincing of their *more distant* deleterious effects. The readiness with which draymen and others, who are in the habit of drinking large quantities of porter, succumb to the slightest injuries—a mere scratch or bruise being frequently followed by erysipelatous inflammation, ending in death—has long been remarked by London practitioners; and every medical man must have seen numerous cases in which a "bad habit of body," influencing most unfavourably the course of disease, was the result of habitual over-indulgence in intoxicating liquors.

That spirits or wine may be advantageously employed, under peculiar circumstances, for raising the animal heat, cannot be denied; and in this way a feeling of chilliness may be removed, which, had it been allowed to continue, might have ended in inflammatory disease. A cup of warm coffee, or a basin of hot soup, would, however, in general, answer the immediate purpose equally well, and be more permanent in their effects. A writer in the British and Foreign Medico-Chirurgical Review (vol. iii., No. v., p. 111), gives the following extract from a private letter of Sir John Richardson, bearing upon the point under discussion. "I am quite satisfied," says Sir John, "that spirituous liquors, though they give a temporary stimulus, diminish the power of resisting cold. Plenty of food and sound digestion are the best sources of heat; and a Canadian, with seven or eight pounds of beef or venison in his stomach, will resist the greatest degree of natural cold, in the open air, and thinly clad, if there be not a strong wind. We found, on our northern journey, that tea was much more refreshing than wine or spirits, which we soon ceased to care for, while the craving for tea increased." The reviewer adds: "We have had personal assurance to the same effect from Dr Richard King, who accompanied Sir George Back in his overland expedition in search of Sir John Ross; and he further mentioned, that whereas he had been previously accustomed to reject every particle of fat, owing to the dislike he felt for it, he found himself able, during his Arctic journey, to eat any amount of it with relish, and even experienced a positive craving for it." We continue the quotation, as it still bears upon the subject, and gives additional corroboration to the views expressed in former parts of this work: "Everything seems to point," says the writer, "to the oleaginous articles of diet, as those best adapted to sustain the animal temperature; the disposition to employ them, and the power of assimilating them, increasing with the demand for the generation of heat. We shall add one more testimony to the same effect. Not long since, we fell in with an intelligent man of above seventy years of age, who had spent more than fifty winters as a fowler on the southern coast of England. It is well known that this pursuit is more successful in proportion to the severity of the weather, a larger number of birds being driven to the south the more intense the cold of winter. Our informant had frequently been out for a fortnight at a time, without lying down, save in his boat, and scarcely ever obtaining warmth from a fire; and notwithstanding, he is a remarkably hale and hearty man for his years. Being himself the proprietor of a public-house, he cannot be supposed to have any indisposition to the use of fermented liquors, in which he indulges

in moderation; but his very explicit testimony to us was, that although the use of ale or brandy might seem beneficial in causing the cold to be less felt at first, so that when out for a day or two he did not think it necessary to abstain from it, the case was quite reversed when the duration of the exposure was prolonged, the cold being then more severely felt, the larger was the proportion of fermented liquors taken. And he further stated, that all the fowlers who had been accustomed to employ brandy with any freedom, when out on prolonged expeditions, had died early."

If it be asked, whether I go the length of proscribing all fermented liquors, from table-beer upwards—I answer that I do not; I merely mean, that, *where the general health is perfect without them, they ought not to be taken, because then their only effect is to produce unnatural excitement.* But wherever the constitution or health is so deficient, or the exertions required by the mode of life are so great, that the system cannot be sustained in proper vigour without some additional stimulus, I would not only sanction but recommend the use of either wine or such other fermented liquor as should be found by experience to support the strength, *without quickening the circulation, exciting the mind, or disordering the digestive functions.* If, however, any of these effects should be produced, I would consider its occurrence as a proof that the stimulus is improper, and cannot be too soon discontinued, or at least diminished to such a quantity as shall be consistent with the ordinary action of the animal functions.

It may be alleged that a glass of brandy after a heavy dinner facilitates digestion, and therefore cannot do harm. I admit at once, that, when we eat too much, or fill the stomach with indigestible food, a dram of brandy, from its temporary stimulus, enables us to get rid of the load sooner than we could without it. But it seems to me a far wiser plan to abstain from eating what we know to be oppressive to the stomach; since we shall thus attain our end infinitely better than by first eating a heavy meal and then taking a stimulus, the efficacy of which is diminished by every repetition of its use. If we were *compelled* to exceed the bounds of moderation in eating, there would be some apology for our conduct.

CHAPTER XV.

ON THE PROPER REGULATION OF THE BOWELS.

Functions of the intestines—The action of the bowels bears a natural relation to the kind of diet—Illustrations—And also to the state of the excretions of other organs—Practical conclusions from this—Different causes of inactivity of the bowels—Natural aids to intestinal action—General neglect of them—Importance of healthy action of the bowels—Bad health from their neglect—Importance of the excretion by the mucous membrane of the bowels—Indications of the tongue—Caution necessary in administering purgatives—Use of air in the bowels—Influence of the brain on the bowels—Natural means preferable to purgatives—Proper use of the latter—Judicious management of the bowels peculiarly important at and for some years after puberty—Regularity of their action desirable—Influence of habit—Aids to weak action should vary with circumstances—Concluding remarks.

HAVING now taken a general view of the objects, nature, and laws of digestion, and of the structure and mode of action of the various organs concerned in its performance, and expounded, as well as I could, the principles on which our conduct ought to be regulated, so as to second the intentions of Nature for our welfare and happiness, I have only to add a few practical remarks on the proper management of the bowels, and then conclude.

The proper uses of the intestines are, as we have seen, 1*st*, To take a share in the performance of digestion; 2*dly*, To afford a surface for the absorption of the nutritive principles; and, 3*dly*, To act as a reservoir for the indigestible residue of the food, and an outlet both for it and for the effete matter which requires to be expelled from the general system. The processes of chylification and absorption having been already treated of, it is in

the third capacity only we have now to consider the intestinal canal.

Besides the bowels, there are several other channels by which the waste materials of the body pass out. The most important of these are the skin, the lungs, and the kidneys; and in certain circumstances, where the action of one of them is impaired or repressed, the natural alliance subsisting among their respective functions enables the rest to come to its assistance, and even for a time to supply its place. Thus, when, by continued exposure to cold, the exhalation from the skin is much diminished, the blood is thrown in upon the internal organs in larger quantity, and, as a consequence, the urinary secretion and the exhalation from the lungs are both increased, and full relief to the system is temporarily obtained. During hot weather, on the other hand, when the skin is in high action, and perspiration flowing freely, the urinary secretion is greatly lessened. The same principle applies equally to the case of the bowels; and hence, the sudden application of cold to the surface of the body, and consequent suppression of perspiration, often increase the intestinal secretions to such an amount as to induce bowel-complaint. On the other hand, the action of the bowels excited by laxatives, tends equally to diminish the activity of the skin; and here, indeed, is one source of the *cooling* effect of saline purgatives administered in fever and inflammations.

The bowels being thus the outlet of the indigestible portion of the food, and of waste matter from the system, it follows that in health their action ought to bear a relation to the kind of aliment used, and to the state of the other excretory functions; and consequently, that *what may constitute healthy action at one time, and in one individual, may be very far from presenting the same character at another time, and in a different individual.* If, for example, a person be fed chiefly on milk and farinaceous aliment, which are almost entirely appropriated to the purposes of nutrition and the generation of heat, and leave very little residue, the bowels, having little to throw out, will naturally act seldomer and less fully than when the diet consists chiefly of bulky and innutritious vegetables, which leave a large portion of indigestible matter to be evacuated. Most persons are aware of the difference of effect between the two kinds of diet, but, from not being acquainted with the principle on which it depends, are apt to conclude that, because in the first case the bowels act less, therefore they ought to be assisted by laxatives. The inference, however, is by no means necessarily sound; because the diminished intestinal action consequent on a diet which is almost all assimilated, is then the natural and healthy result; and accordingly, *where such diet is required, and is not used in excess*, the mere costiveness is attended with no injury to the constitution. The proper conclusion to be drawn from it is, that the permanent and exclusive use of concentrated food is not in harmony with the structure and functions of our digestive and assimilating organs, and that therefore, instead of continuing their use, and merely resorting to purgatives to excite an action for the removal of a residue which does not exist, reason demands that we should select a diet better adapted to the constitution and laws of the organism by which it is to be acted upon.

The same remark applies to those who are accustomed to dine chiefly on animal food, and rice or bread, without any sufficient admixture of herbaceous or other comparatively innutritious substances. If, in such circumstances, the aliment be almost entirely converted into nourishment and absorbed, it follows of necessity that little will remain to be thrown out of the body, beyond the excretions of the mucous surface and the liver and pancreas, and that the bowels will act less than with a different kind of diet. I once met with a very singular case somewhat of this nature, in which there was no relief from the bowels for six weeks, and then only in the form of little hard balls, resembling the excrement of the sheep. However incredible

this statement may appear, I have reason to believe in its perfect accuracy; but I scarcely need add that, in this instance, both health and nutrition were seriously impaired. If the state of the constitution at the time be such as to require the exclusive use of this kind of aliment, forced action of the bowels by purgatives will not be needed, because their slowness will be natural and healthy. But if no such diet be requisite, then the proper remedy is not to excite the bowels by irritating purgatives, but, if possible, to remove the cause of the intestinal inactivity by a better regimen, and by medical treatment suited to the nature of the disease.

It may be objected to this, that there are many instances in which the stomach is unable to digest any herbaceous or bulky food, and in which, consequently, the diet cannot be altered without injury. I admit that, in the present state of society, where the laws of the animal economy are so generally disregarded, cases of this kind are not uncommon; but their number would be greatly reduced if a proper mode of life were systematically adopted, and that regard paid to the conditions of health which their intrinsic importance deserves. There are very few individuals who, when in health, and with the aid of a proper regimen, cannot digest aliment suited to the natural constitution of the stomach and bowels; and when such cases do occur, they constitute exceptions to the general rule, and must, of course, be treated either by the use of laxatives, or by such other remedies as the circumstances may require.

As the frequency and amount of the intestinal evacuations may thus vary according to the nature of the diet, without necessarily involving any disturbance of health, so may they also *vary according to the state of the other excretions;* and hence, again, may be deduced the absurdity of considering the same standard as applicable alike to all persons, times, and circumstances. It is a prevalent notion that the bowels should act at least once in twenty-four hours; and there are thousands of persons who, if they fail to do so under any circumstances, immediately resort to the use of purgatives, and who consider this regular repetition of medicine as hardly less necessary to their continued existence than the daily repetition of their dinner. In Britain this practice has amounted almost to a mania both in and out of the profession; and in many instances its consequences have been disastrous. So far from daily evacuations being required in all cases and under all circumstances, their occurrence would frequently be attended with disadvantage. There are many constitutions in which the most vigorous health is enjoyed, where the bowels act only once in two or even three days, and where a daily evacuation would be an indication of some bodily disorder. In such individuals the frequent use of purgatives can lead to nothing but mischief. In like manner, when, from continued exertion, perspiration is kept unusually active, the excretion from the bowels may be proportionally diminished, not only without injury, but even with advantage to the health; because, if the same waste were to go on by the bowels as before, and the increased exhalation from the skin were also to continue, the system would speedily become reduced. In consumption, for example, exhausting bowel-complaint and profuse perspiration are frequently observed to alternate, and whatever remedy is given to check the one generally aggravates the other. But if *both* were to run their course together instead of singly, how much more rapidly would the system be undermined!

From this relation between the different excretory functions, it follows that, when sluggishness of the bowels in induced by excess in another excretion, the first step should be to remove or diminish the unnatural stimulus which has occasioned that excess, before attempting, by means of purgatives, to *force* the bowels to act. If the cause which has produced the deviation from the due proportion of the excretion be left unabated, the only effect of strong laxatives will be,

not to relieve, but to irritate and weaken.

The mere fact of the bowels not being emptied so frequently as usual, is, therefore, when taken by itself, no evidence that they should be stimulated by medicine. Before coming to this conclusion, we ought to ascertain clearly whether the diminished action results from morbid sluggishness of the intestinal canal, or is the natural result of an accidental change of diet, or of temporary excess in the other excretions; because the remedy which is proper and efficacious in the one case, may be altogether inapplicable to the other. When it arises entirely from the aliment leaving little residual matter to be thrown out, the health may suffer *from the diet being unsuitable*, but it will not suffer merely from the diminished action of the bowels: whereas, when the diet is of the ordinary mixed kind and the cutaneous and other excretions are not too copious, and the costiveness proceeds from morbid inaction, then general derangement of the system will be induced, unless the bowels be attended to, and their natural action restored. This distinction ought never to be lost sight of.

Judging from the prevalent notions on the subject, from the general reference of all kinds of bad health to derangement of the stomach and bowels as their source, and from the scarcely less universal abuse of purgatives as remedial agents, one would be apt to suppose that, to ensure health and long life, nothing more was required than to procure, no matter by what means, frequent and copious intestinal evacuations; and the inference would, to a certain extent, be confirmed by the acknowledged extensive utility of laxatives medicines. The real state of the case, however, is not quite so simple; and as a knowledge of it is important, I shall here explain it as clearly as I can.

We have seen that inactivity of the intestinal canal may arise from the use of too concentrated aliment, and from excess in the excretions of other organs. In the majority of cases, however, the cause is very different. In general, the diet is sufficiently varied and abundant, and the balance of functions sufficiently perfect, to leave a considerable quantity of alimentary residue and effete matter to be thrown out by the bowels; and if it is not regularly expelled, some obstacle of a different kind must exist, which ought to be removed in the first place, before we can expect to succeed in restoring the natural action. To enable us to discover what that obstacle is, let us turn our attention for a moment to the natural means by which the intestinal evacuations are effected.

The progress of the intestinal contents along their canal depends, first, on their affording the necessary stimulus to excite the contraction of the muscular coat; secondly, on the assistance derived from the free action of the abdominal and respiratory muscles, not only during respiration, but during every kind of bodily exercise; thirdly, on the inner surface of the intestine being duly lubricated with the mucous secretion; and, fourthly, on a due supply of nervous influence from the brain. If any or all of these conditions be wanting, the inevitable result will be morbid sluggishness of the intestinal action, and the various consequences dependent upon it; and hence, when the evil exists, the first point to be determined is the nature of the cause by which it is produced.

1. As already remarked, farinaceous, gelatinous, and other concentrated aliments do not afford the requisite stimulus to the muscular fibres of the intestine; because they are in a great measure absorbed, and leave little to be thrown out. If, therefore, concentrated food be the cause of costiveness, the proper remedy is to alter the diet, and to have recourse to other means only where that proves insufficient. If, again, the inactivity of the bowels proceed from the food not being sufficiently digested, whether from deficiency of bile or any other cause, and from their contents being on this account inadequate to excite them to healthy and regular action, it follows as a necessary consequence, that, before we can obtain intestinal regular-

ity, digestion must be improved by steady perseverance in a proper regimen, and such other means as may be required to improve the general health. It is in cases of this description that the practitioner is most frequently consulted, and that he has the best opportunity of shewing his discrimination and judgment. If he and the patient are satisfied with simply procuring relief, he has ready means at hand, in any of the ordinary purgatives. But if a *cure* is their object, they must go back to the root of the evil, and begin by restoring the digestive organs to health.

The observance of a proper adaptation between the quantity of the food and the state of the digestive organs and mode of life, and the habitual fulfilment of the conditions required for healthy digestion, are, then, not less essential to the proper action of the bowels than to that of the stomach. If we eat more than the system requires, or act in contravention to the laws of digestion, the bowels become oppressed and weakened by their load; and it is in such circumstances that purgatives afford immediate relief by the removal of the superfluity, and, by blinding the individual to the real nature of the evil, tempt him to recur too frequently to the use of medicines.

2. Where, however, as most frequently happens, the constipation arises chiefly from the absence of assistance from the abdominal and respiratory muscles, and only in part from an unsuitable diet, the first step to be taken is to secure the aid of these muscles—first, by removing all impediments to free respiration, such as stays, waistbands, and belts; and, secondly, by resorting to such active exercises as shall call the muscles into full and regular action: and the next step is to proportion the quantity of food to the wants of the system, and the condition of the digestive organs. If we employ these means systematically and perseveringly, we shall rarely fail to restore at last the healthy action of the bowels, with little aid from medicine. But if we set these natural conditions at defiance, we may go on for years, adding pill to pill, and dose to dose, without ever attaining the end at which we aim.

How, indeed can it be otherwise? If the Creator has so constituted us that the free play of the lungs and muscles is indispensable to proper intestinal action, and to the health of the contained abdominal organs, it is in vain for us to struggle against the arrangement, and expect to substitute beneficially the stimulus of purgatives for that of the natural play of the muscles. Either we must give up our own obstinate adherence to sedentary pursuits and conform to the Divine laws, or we must submit to the suffering inseparable from our neglect, and merely endeavour to mitigate its severity by such partial remedies as lie within our reach.

Where bodily weakness, or any other cause, absolutely prevents us from engaging in active bodily exertion, corresponding moderation in eating, and continued kneading and rubbing over the region of the bowels, persevered in daily till the strength be restored, are of great service in promoting their healthy action. Where great sluggishness of the bowels exists, and no exercise can be taken, the rubbing generally requires to be continued for an hour or two daily, or even twice a-day.

3. Sometimes intestinal inaction proceeds from defective mucous secretion on the surface of the internal coat, caused either by errors in diet or by local irritation. When costiveness is produced in this way, a mild diluent regimen will generally remove it. It is in such cases that saline medicines, which act by increasing the mucous secretions, are often very useful; while aloetic and other stimulant purgatives increase the evil by aggravating the irritation.

But it should never be forgotten that there are certain states of the system in which constipation or inaction of the bowels is a symptom of grave import. The mucous coat of the bowels is studded throughout its whole length with innumerable small glandular bodies, whose office it is to excrete the effete

matter of the system into the intestinal canal. In this respect the function of the mucous membrane is precisely analogous to that of the skin; the only difference being, that, in the former case, the excretions are for obvious reasons collected in a receptacle in order to be evacuated at convenient times, while in the latter the transpiration escapes directly into the atmosphere. We are all familiar with the bad effects of checked perspiration: the effects of checked excretion by the mucous coat of the bowels are not less injurious, though less palpable to cursory observation. That fæcal matter is excreted by the mucous membrane, is proved by everyday experience, as it continues to be evacuated in cases where no food is taken. Constipation may, therefore, depend on this effete matter being retained in the system; and accordingly, when it is not habitual, but occurs in an unusual and sudden manner, it should never be neglected, especially when accompanied by a feeling of feverishness and discomfort. In certain diseased conditions, the quantity of effete matter which is evacuated by the bowels is enormous. In a remarkable case which was under the care of Dr Graves,* and in which very great quantities of thin black matter were passed for ten or twelve days in succession, "the black colour was evidently derived from the mucous membrane," as was proved by the absence of disease of the liver, and by the following experiment:—"I cleaned," says he, "one-half of the tongue, from which I washed, with much difficulty, the black tenacious mucus. I watched it for several hours, and found that the part I had cleaned became gradually black and foul, the black mucus being evidently a secretion from its surface." The reader may learn from this passage that the reason why the physician inspects the tongue of his patient is, that he may judge from its clean or loaded appearance whether the excreting function of the intestinal mucous membrane is in a healthy state.

It is familiar to persons conversant with disease, that frequently the course of a malady is favourably determined by copious critical evacuations from the bowels. There are certain conditions, however, in which the appearance of the discharged matter is apt to mislead the ignorant and unwary, and much harm is occasionally done by giving active purgatives to remove an abnormal state of the evacuations which is owing to an already irritated condition of the mucous membrane. This mistake is most frequently committed with children, who are apt to be affected with a greenish discharge. The colour is taken (for the most part erroneously) as an indication that the liver is out of order, and calomel is at once had recourse to. But the proper treatment, in such cases, consists in the adoption of soothing measures to remove the intestinal irritability.*

The natural tendency of muscular fibre being to contract, it may naturally be supposed that, after the intestine is emptied, its opposite sides will come into contact, and, by thus obliterating the cavity altogether, present an obstacle to the subsequent passage of any solid matter. But on inspecting the abdomen after death, we rarely meet with any considerable portion thus contracted; and, in general, the whole intestines are distended to a greater or less degree, according to circumstances. The agent by which this effect is brought about, is one known more familiarly by the inconveniences and pain to which it gives rise when in excess, than by its proper uses, which are nevertheless important. I allude to the presence of air in the bowels, which is as necessary to their healthy action as their muscular contraction itself. Air, in fact, by its expansive energy, forms the antagonistic power to the muscular coat, and serves to dilate the bowel after the requisite contraction has propelled its contents. A certain degree of distention, indeed, not only is a stimulus to farther muscular contraction, but is useful in facilitating the passage of the subsequent portions of the feculent matter; and hence the injection of air into the bowels in large quantity, has lately

* Clinical Lectures on the Practice of Medicine, vol. ii., p. 219. Dublin, 1848.

* *Vide* Graves, vol. ii., p. 221.

been employed successfully in overcoming obstinate constipation.

4. There still remains one other cause of constipation to be noticed. We saw in Chapter XI. that the condition of the brain exercises a decided influence upon the functions of the stomach; and there can be no doubt that this influence extends, though in a less remarkable degree, to the functions of the bowels. Thus, when the brain is inflamed, or is merely oppressed by congestion, constipation is generally a concomitant symptom; and we have unequivocal proof of the influence of mental emotion on the bowels in the effects occasionally produced by fear. Indeed, intense mental occupation is as unfavourable to the regular and healthy action of the bowels, as (for the reasons explained at p. 114) it is to gastric digestion; and constipation thus not unfrequently arises from the calls of nature being unperceived, or remaining unheeded, owing to the concentration of the mind in writing or reading. On this account it is highly desirable that persons whose bowels shew a tendency to constipation, should refrain from mental occupation immediately after breakfast, the reading of the newspaper being alone often sufficient to prevent the intestinal action which otherwise would then ensue. It is in this way that the constipation which afflicts literary men frequently originates. When the nervous energy has been concentrated in the brain by intense and long-continued study, by great anxiety, or prolonged excitement of any kind, the bowels cease to receive their due supply of nervous stimulus, and their action is consequently impaired. The muscular coat ceases to contract with sufficient energy, and its lowered tone thus favours the continuance of the constipation which originated in deficient nervous power. In such cases the first remedial measure is to remove the source of the excessive mental excitement or occupation, and the second to restore the lost tone of the bowels by suitable treatment.

Such being the mode of action of the bowels, and such the natural agents by which it is carried on, we can now appreciate the folly of seeking to apply the same remedy to every kind of costiveness, no matter from what cause it proceeds. If a clerk who sits motionless all day in an office, who indulges his appetite, and has no bodily exercise to facilitate respiration and give a natural impetus to the bowels, begins after a time to complain of constipation, it is not difficult to tell what is required for his cure. The first step which a knowledge of the animal functions would suggest, is to diminish the food to such a quantity as the system requires and the stomach can digest; the next, to use such a diet as is calculated to excite the muscular coat of the intestine to healthy activity, and fulfil strictly the other conditions shewn to be essential to healthy digestion; the third, to seek the natural aid to intestinal action, arising from exercise of the abdominal and respiratory muscles; the fourth, to increase and improve the excreting action of the mucous membranes by exercise and the consequently increased inhalation of oxygen, on the free supply of which all healthy action is peculiarly dependent; and the last of all, to have recourse, when necessary, to such medicines as may for a time be required to restore the tone of the bowels, and enable them to act without further assistance. The usual course, however, is widely different. From ignorance of the laws of organization, the patient is not aware of the extent to which he infringes them in his conduct, and consequently rests satisfied with lamenting his hard fate, and resorting to strong medicines to *force* that action which he feels to be essential to health, but which ought to be elicited by the means with which Nature has furnished him.

Among the middle and higher classes, very many females act on the same erroneous plan, and with equally unfortunate results. In them the evil is aggravated by the tightness of their dress impeding almost entirely the descent of the diaphragm, and the free play of the abdominal muscles, in respiration.

From this view of the nature and causes of costiveness, it will be evident, that, as a general rule, the bowels are perfectly competent to the performance of their functions, when the conditions essential for their healthy action are duly fulfilled. And hence, whenever they become morbidly inactive, we may rest assured, that, in some point or other, our own management is or has been defective; and the surest way to remedy the evil is, not to have instant recourse to medicine, but to begin by discovering and amending the defect. In the rarity with which constipation occurs among children and other actively employed persons, we have ample proof of the fundamental principle that the bowels do not naturally stand in need of the stimulus of medicine, but require only to be properly treated to fit them for their office.

While, then, I entirely agree with public opinion in attaching great importance to the proper regulation of the bowels, and in tracing much suffering to their neglect, I am only the more anxious that we should, as far as possible, follow Nature in our arrangements, and reap the benefit of her aid. If we do so, we shall not only be less frequently obliged to have recourse to medicine, but, by our knowledge of the causes of the deficient action, be greatly assisted in our selection of a suitable kind of laxative, and thus avoid forcing the constitution too far. It sometimes happens, for example, that, from debility of the muscular coat, the peristaltic motion is insufficient to propel the contents of the intestines, even with the aid of proper diet and exercise. In such cases, small doses of aloes or rhubarb, or other laxatives which act chiefly by exciting the muscular contraction, will be sufficient to clear the bowels, especially when any mild tonic is conjoined with them; while saline laxatives, which act chiefly on the mucous coat, may be given freely, and even cause numerous watery evacutions, and yet the real or solid contents of the intestines continue unremoved. In practice this often happens; and hence the frequent mistake of supposing that there is proper passage from the bowels, when in reality there is no such thing. Another mistake has already been noticed on page 34.

The period of life at which intestinal inactivity, and the mismanagement in which it generally arises, are attended with the most serious consequences, is at, and for a few years after, puberty. At that age a sudden change is often made from the restless activity of youth to the stillness of a sedentary profession, without any corresponding alteration being made in the quantity of food consumed. The vigorous appetite which is perfectly natural during a period of growth and great bodily activity, remains at first unimpaired, and impels the individual to eat an amount of food far beyond the present necessities of the system or the powers of digestion. The consequence is a tendency, not only to fulness from excessive nutrition, but to obstinate digestive disorder, from the stomach and intestines being weakened by want of exercise and by excess of food. From pretty extensive observation, I am confident that a large proportion of the severe dyspeptic cases attended with great derangement and imperfect action of the bowels, which occur, in what are considered regular living men, on the approach of manhood, or between twenty and forty years of age, are fairly attributable to this cause, and might be avoided by the exercise of a rational foresight; and I have known several, who suffered severely in this way for years, emphatically lament the ignorance which betrayed them into the error. There are many persons, no doubt, constitutionally too devoted to intemperance to be corrected by any such considerations; but there are also many, misled less by the force of appetite than by ignorance, who may profit by the remark.

After the preceding observations were written, I was struck with a remarkable confirmation of them in the excellent work published a few years ago by Mr Parker of Birmingham, "On the Stomach and its Morbid

States." After describing the mode in which repeated attacks of gastric irritation ultimately induce disorganization of the stomach, Mr Parker says: "I have had the charge of several patients in the later stages of gastric diseases, who have been able distinctly to trace the commencement of their complaints. *These have seldom commenced before the age of twenty-five*, at the periods when they had begun the habitual use of a fuller and more stimulating diet than that of the earlier periods of life. The symptoms with which they were first affected were those of simple indigestion in its various forms of pain or distention after food, nausea, or vomiting. These have ceased at intervals, have been relieved by various plans of treatment, but have shewn a disposition to recur at longer or shorter intervals from dietetic errors or excesses, or from other causes, in more aggravated and obstinate forms than those in which they first made their appearance, and accompanied by sympathetic irritations in the head, heart, liver, or lungs, exhibited in the forms of giddiness, palpitations, jaundice, or cough." "Many of the patients in whom dyspeptic symptoms have commenced about the ages of twenty or thirty, have fallen victims to gastric diseases and their complications at the ages of from forty-five to fifty-five."—P. 47. Mr Parker supports his position by numerous cases, the histories of which are detailed by the patients themselves; and, with the slight difference that he speaks of the patients *beginning* the use of the full and stimulating diet at twenty-five, when, according to my observation, their error consisted rather in *continuing* the full diet of earlier life, we entirely agree in opinion. The effect is, however, much aggravated when, to mere excess in quantity, a stimulating quality is added, such as arises from the indulgence in wine or ardent spirits, common enough in young men at the age to which Mr Parker refers. In such circumstances, it is not the stomach alone which suffers; the bowels also become seriously disordered, lose their natural tone, and thus seem to demand the constant aid of medicine. In one case, arising purely from excess of eating after growth had finished, four years of continued bad health in an otherwise sound constitution were painfully spent before the real cause was accidentally discovered. During all that time, too, temporary relief invariably followed the use of purgatives, and seemed in some measure to point to the truth; but from the mind never having been directed to the principles, its practical bearing was overlooked, and now the individual wonders that the cause did not, even at first sight, arrest the attention of his medical advisers.

In cases of this description, however, it ought to be observed that it is not the mere constipation which injures the health and requires to be removed. It is in reality to *the mode of life which induces the constipation* that we should direct our attention; for, unless that be amended, all our efforts to preserve the health by merely removing the effect will prove insufficient. Medical men ought to point out this fact to their patients.

In the natural and healthy state, under a proper system of diet, and with sufficient exercise, the bowels are relieved regularly once every day. In some constitutions, however, the ordinary period is shorter or longer than this—twice a-day, or only once in two days; but such differences are unimportant when they do not proceed from morbid causes or in any way disturb the health. Habit, in this as in other operations under the influence of the nervous system, is powerful in modifying the result, and in sustaining healthy action when once fairly established. Hence the advantage of observing as much regularity here as in taking our meals, and the impropriety of breaking through the habit when once formed. Sleep seems to be favourable to the progress of nutrition, and it is apparently during the night that the assimilation of the daily food is completed and its residue prepared for being expelled. At all events, there is a natural tendency in the bowels to act in the morning, and we ought to en-

courage it by a voluntary effort. Even the reception of breakfast into the stomach seems to act as a stimulus to intestinal contraction; for many persons experience the inclination immediately after their morning repast, and suffer if they are prevented from yielding to it.

Where, either from constitutional weakness, sedentary occupation, or other unavoidable causes, the bowels are unable to act sufficiently to relieve the system without assistance, we have, of course, no choice but to select that which is most suitable to the circumstances and most gentle in its operation; because, if assistance be not afforded, the health will assuredly suffer. Numerous examples of this kind are met with every day, and, when treating them, we should always aid Nature by a fit diet and regimen, and not trust to medicine alone for rectifying the consequences of the patient's misconduct. In the great majority of cases, the action of the bowels may be restored with little or no aid from medicine, provided a suitable regimen be observed, and the result be awaited with patience and prudent forbearance. I have seen many examples of this fact in persons who had been accustomed for years to the use of purgatives, and believed they could not exist without them. Some inconvenience was experienced at first, and caution was required in determining how far to trust to the efforts of Nature; but in no instance did any bad consequence result even from considerable delay, when precautionary means were used to prevent them. In this, as in other instances, we ought never to lose sight of the great truth, that, if the bowels were originally constituted with power to act sufficiently on the application of their own stimulus, food, there must necessarily be a wide departure from the organic laws in some part of our conduct to cause the loss of that power; and therefore, whenever we find the bowels unable to act without medicine, our first business ought to be to discover and rectify our error—and recourse should be had to medicine only in so far as it is necessary to remedy the consequence of the transgression.

As the sole object of the present volume is to make the reader acquainted with the *natural* laws of the animal economy, and with the means by which aberrations from them may be prevented and health preserved, I shall not enter upon the discussion of either the morbid conditions of the bowels, or the remedies by which these may be cured—and consequently shall say nothing farther of the use of purgatives or other medicines. The consideration of these matters is not only foreign to my purpose, but would require an extent of detail much beyond my present limits. When disease exists, medical advice should be procured without delay.

Perhaps some will think that, before concluding, I ought to apologise for having introduced to the notice of the general reader such homely subjects as those discussed in this and some of the former chapters. But, in doing so, I have been actuated by a deep sense of the misery arising from the prevailing ignorance on topics which, although in themselves as interesting and important as any to which the human mind can be directed, have nevertheless been passed over in silence, partly from not the least suspicion being generally entertained of their real bearing on our health and happiness, and partly also from false notions of delicacy diverting attention from their calm and deliberate examination. In endeavouring, therefore, to unfold, in the language of reason, what I conceive to be useful and momentous truths, I confess that I feel no apprehension that any well-constituted mind will receive contamination from the perusal of these pages.

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